RK
& Associates, Inc.

March 1, 2012

R06337

Ms. Rachel Rineheart
U.S. Environmental Protection Agency
Region 5
77 W. Jackson Blvd.
Chicago, IL 60604

Endangered Species Analysis
Washington Mills Hennepin, Inc. - Hennepin, Illinois
Site Identification No.: 155801AAC

Dear Ms. Rineheart:

Washington Mills Hennepin, Inc. (WMH) is proposing to install a new sixth furnace group (C6) to increase its SiC production capacity and provide increased operating flexibility. This report evaluates the potential impacts of the proposed WMH expansion to threatened or endangered species populations and their critical habitats as requested by U.S. EPA Region 5 pursuant to Section 7 of the Endangered Species Act (ESA). This report contains an assessment of potential short-term effects, including acute toxicity and the potential for acid fog, and an assessment of long-term effects, including chronic toxicity, accumulation of metals in soils, surface water and sediment, and bioaccumulation in Indiana bat populations.

Conclusions are drawn as to the overall potential for detrimental impacts of the proposed WMH modifications on federally listed species. The assessments in this report are updated from the previous Endangered Species Evaluation report for the fifth furnace (2008) to reflect the current evaluation related to the planned addition of the sixth furnace, including emission increases associated with this planned addition and current conditions.

If you have any questions regarding this report, please do not hesitate to contact me at 630-393-9000.

Yours very truly,
RK & Associates

Suresh Relwani
Principal Engineer

CC: Armand Ladage – Washington Mills Hennepin

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Endangered Species Evaluation

Washington Mills Hennepin – Hennepin, Illinois
Site ID No. 155801AAC

Feb 8, 2012

R06337

Prepared for:

Washington Mills Hennepin
13230 ESK St
Hennepin, Illinois – 61327
Attn: Mr. Armand Ladage

Submitted to:

U.S. Environmental Protection Agency
Region 5
77 W. Jackson Blvd.
Chicago, IL 60604
Attn: Ms. Rachel Rineheart

Prepared by:

RK & Associates, Inc.

RK

& Associates, Inc.

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENT

1.0 INTRODUCTION

Washington Mills Hennepin, Inc. (WMH) is one of the world's largest producers of high grade silicon carbide (SiC) and the only producer in the United States. WMH operates an existing SiC production facility located in Putnam County northeast of the City of Hennepin, Illinois. See Figure 1-1 for a map of the WMH facility and its surrounding environs.

WMH is proposing to install a new sixth furnace group (C6) to increase its SiC production capacity and provide increased operating flexibility. Pursuant to the Clean Air Act (CAA), WMH is seeking a permit under the U.S. EPA Prevention of Significant Deterioration (PSD) Program for this proposed facility expansion. EPA's issuance of such a permit may trigger Section 7 of the federal Endangered Species Act (ESA), which requires that federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species or result in the destruction or adverse modification of designated critical habitat.

This report provides the results of an evaluation of the potential effects of the proposed action on federally listed threatened and endangered species protected under the ESA. The list of species, including the Indiana bat (*Myotis sodalis*), eastern prairie fringed orchid (*Plantanthera leucophaea*), prairie bush clover (*Lespedeza leptostachya*), and decurrent false aster (*Bolotonia decurrens*), was provided by Rachel Rineheart from the U.S. EPA, Region 5. The four species are the same as those assessed in the previous Endangered Species Evaluation report for the WMH expansion of the fifth furnace group (see Attachment A).

This report includes a list of species of potential occurrence in the vicinity of the WMH facility; a discussion of emissions resulting from the proposed WMH expansion and their fate and transport; a description of the modeling setup and modeled maximum impact sites; an assessment of potential short-term effects, including acute toxicity and the potential for acid fog; and an assessment of long-term effects, including chronic toxicity, accumulation of metals in soils and sediment, and bioaccumulation in Indiana bat populations. Conclusions are drawn as to the overall potential for detrimental impacts of the proposed WMH modifications on federally listed species. Literature review and modeling setup are included as appendixes.

Figure 1-1: Washington Mills Hennepin Facility Location Map

Washington Mills
Hennepin
13230 ESK Street

	COMMENTS:	Facility Location Map		
RK & Associates, Inc. 2S631 ROUTE 59 SUITE B WARRENVILLE, IL 60555 630-393-9000	Endangered Species Evaluation	**Washington Mills Hennepin** Hennepin, Illinois		
	DRAWN BY::	APPROVED BY::	PROJECT NUMBER R06337	DATE DRAWN: 2-7-12	REVISED DATE
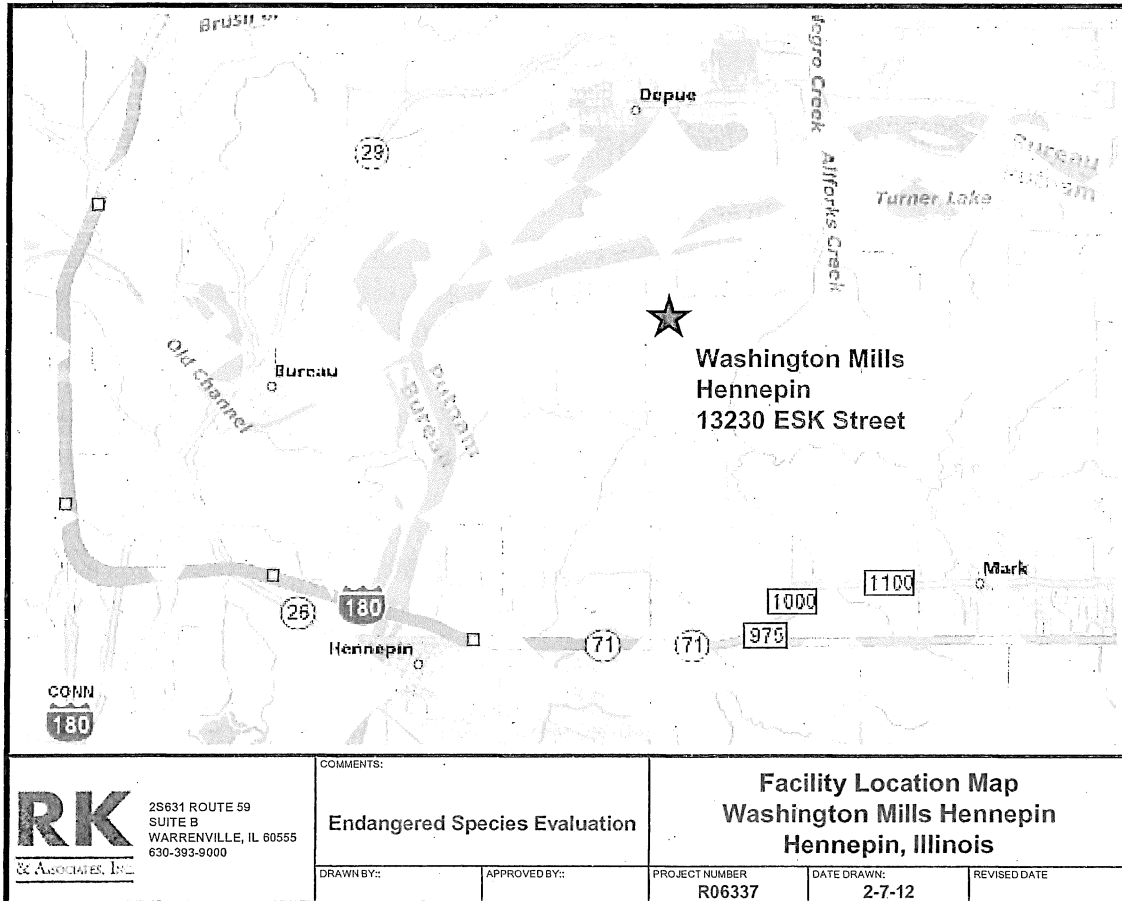
2.0   SPECIES DISTRIBUTION AND CRITICAL HABITAT INFORMATION

The list of federally and state-listed threatened and endangered species that potentially occur in the vicinity of the WMH project area is presented in Table 2-1. Information of federal and state status is from the Illinois Department of Natural Resources, "Checklist of Endangered and Threatened Animals and Plants of Illinois (2011)" at the link: http://www.dnr.state.il.us/ESPB/pdf/2011_Checklist.pdf.

The U.S. Fish & Wildlife Service (USFWS) endangered species web pages (http://endangered.fws.gov/) provide most of the information for each species:

- Maps and descriptions of designated critical habitat

- Recovery plans with distribution descriptions

- Federal Register notices of the listing action.

Potential habitats of the four species in the vicinity of the WMH facility is mapped using land use/land cover data (2006) from the National Land Cover Database (NLCD) (http://www.epa.gov/mrlc/nlcd-2006.html). The colors associated with the land cover classes were redefined using GIS software in order to specifically reflect the habitat preferences of species. The resulting maps are shown in Figures 2-1, 2-2, 2-3 and 2-4. Detailed information of each species was discussed in the previous Endangered Species Evaluation report for the WMH fifth furnace (2008); see Attachment A Section 2 Potential Habitats of Listed Species.

Table 2-1 – Federally and State-listed Species of Potential Occurrence in the Vicinity of WMH

Species Common Name (Scientific Name)	Federal Status	State Status
Indiana Bat (Myotis sodalis)	E*	E
Eastern Prairie Fringed Orchid (Platanthera leuciphaea)	T**	E
Prairie Bush Clover (Lespedeza leptostachya)	T	E
Decurrent False Aster (Boltonia decurrens)	T	T
Note: * -- E represents "Endangered" ** -- T represents "Threatened"		

Figure 2-1: Potential Indiana Bat Habitat in the Vicinity of the WMH Facility Derived from NLCD (2006)

Potential Indiana Bat Habitat

Legend:
- Woods (comuting, roosting, foraging)
- Open water (commuting, foraging)
- Fields (neighboring, foraging)
- Developed or barren (not prefered)
- WMH location

	COMMENTS:		Potential Indiana Bat Habitat		
RK & Associates, Inc. 2S631 ROUTE 59 SUITE B WARRENVILLE, IL 00555 630-393-9000	Endangered Species Evaluation				
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Figure 2-2: Potential Eastern Prairie Fringed Orchid Habitat in the Vicinity of the WMH Facility as Identified by NLCD Land Cover (2006)

Potential Eastern Prairie Fringed Orchid Habitat

Legend:
- Potential Habitat
- Open Water
- Not Potential Habitat
- WMH Location

	2S631 ROUTE 59 SUITE B WARRENVILLE, IL 60555 630-393-9000	COMMENTS:	Potential Eastern Prairie Fringed Orchid Habitat			
RK & Associates, Inc.		**Endangered Species Evaluation**				
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6
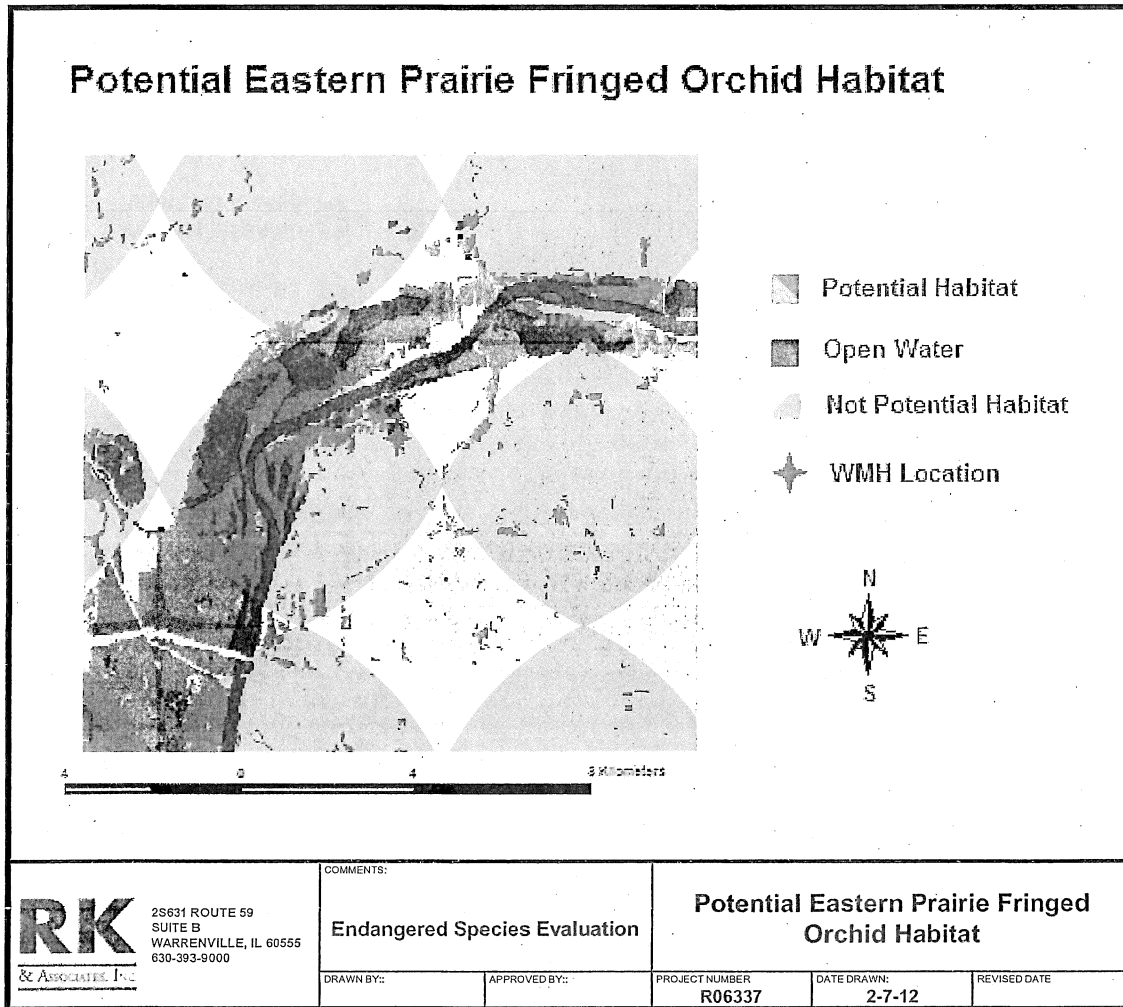
Figure 2-3: Potential Prairie Bush Clover Habitat in the Vicinity of the WMH Facility as Identified by NLCD Land Cover (2006)
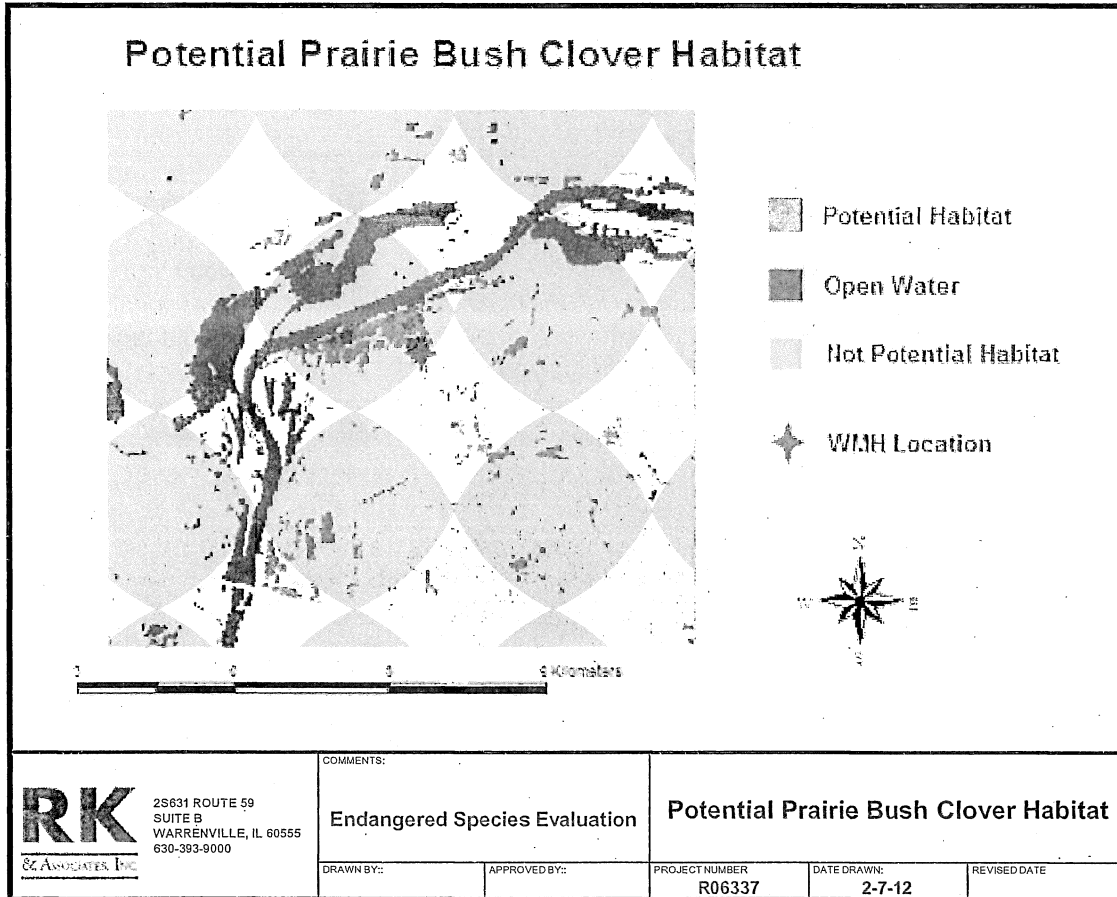
Figure 2-4: Potential Decurrent False Aster Habitat in the Vicinity of the WMH Facility as Identified by NLCD Land Cover (2006)

Potential Prairie Bush Clover Habitat

Potential Habitat

Open Water

Not Potential Habitat

WMH Location

	COMMENTS:		Potential Decurrent False Aster Habitat		
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	DRAWN BY::	APPROVED BY::	PROJECT NUMBER R06337	DATE DRAWN: 2-7-12	REVISED DATE
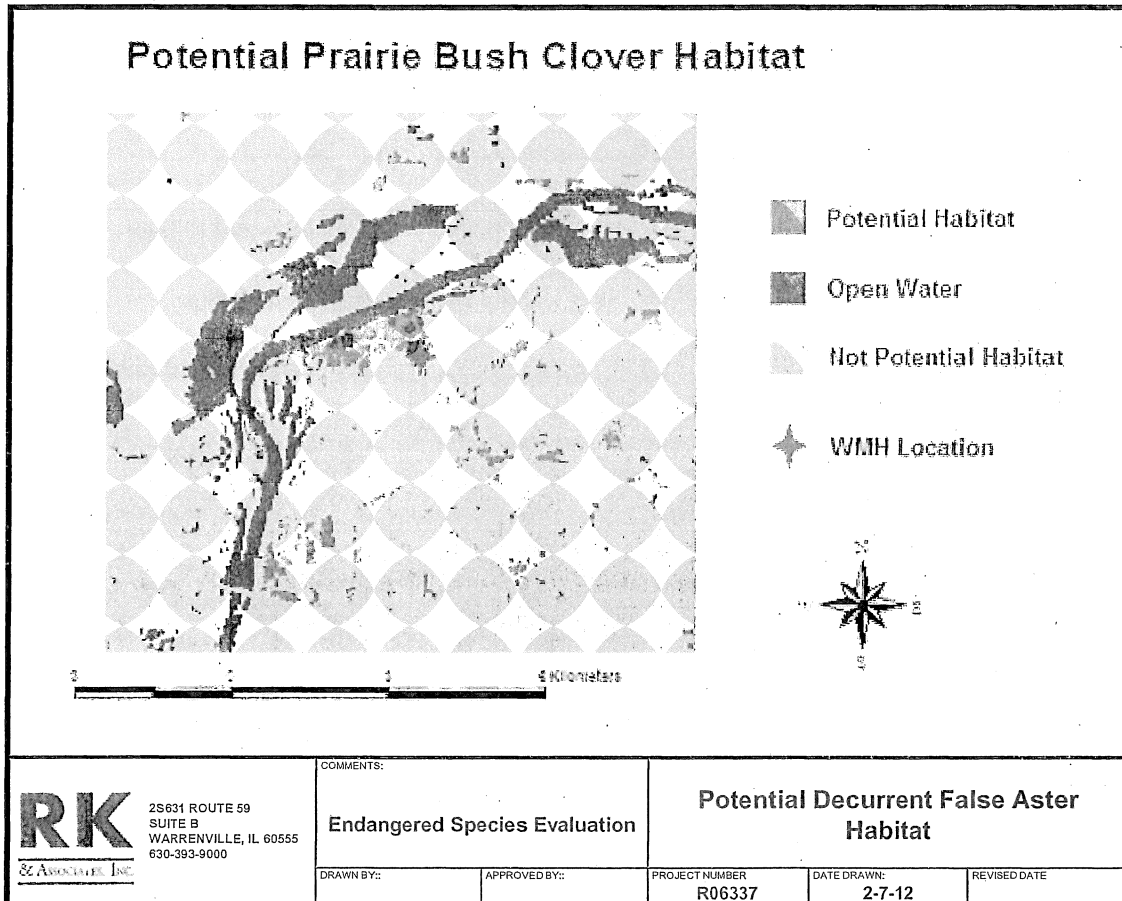
3.0 FATE AND TRANSPORT OF WMH EMISSIONS

3.1 Chemicals of Potential Concern

The WMH facility emits a variety of pollutants to the atmosphere. Sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), several HAPs, and residual sulfur-containing compounds, including carbonyl sulfide (COS), carbon disulfide (CS_2) and hydrogen sulfide (H_2S), are emitted from the facility's stack. In addition, there are some fugitive PM emissions from material handling sources. PM from the incidental material (coke and silicon carbide product) emissions also contains some metals. Three of these metals – aluminum, nickel, and vanadium – are evaluated due to their status as HAPs and/or chemicals of potential eco-toxicity.

The incremental emission increases of pollutants associated with the proposed facility addition of a sixth furnace are summarized in Table 3-1. The incremental increases are comparable to the emission increases assessed in 2008 in connection with the PSD permitting of the fifth furnace at this facility. See Attachment A hereto. Those comparable emission increases were found at that time not to have an adverse impact on any threatened or endangered specifies, and a PSD permit was issued for that furnace addition. A conceptual exposure model summarizing emissions from the WMH facility expansion and the fate and transport of those emissions in the environment were presented in the previous 2008 Endangered Species Evaluation (2008) Attachment A, Section 3.2 "Conceptual Exposure Model". That remains a viable model for use in this report.

3.2 Modeling of Potential Impacts

Dispersion and deposition of pollutant emissions from the WMH facility were modeled using the AERMOD model. The model setup for the acid fog analysis and particulate matter (PM) analysis followed the model setup described in Attachment A, Appendix B. Figure 3-1 below displays receptor sites for gas and PM modeling. As expected, locations of maximum impact receptors for all time scales and species modeled are predicted to be within 3 km radius of the facility.
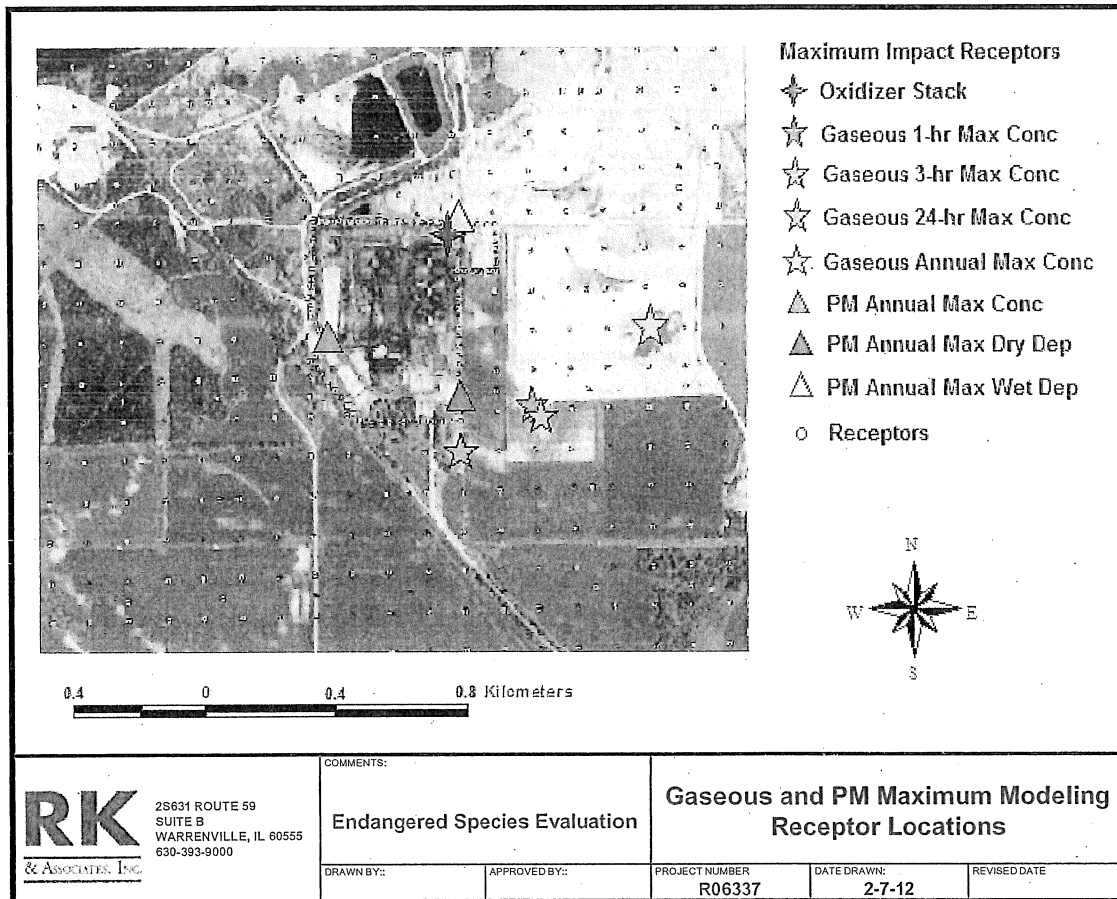
Table 3-1 – Emission Rates of Chemicals of Potential Concern

Chemicals of Potential Concern	Emission Rate (tpy)	Emission Rate (g/s)
Sulfur dioxide (SO_2)	5.07E+02	1.46E+01
Nitrogen oxides (NOx)	3.96E+01	1.14E+00
Total particulate matter	4.87E+01	1.64E+00
Hydrogen sulfide (H_2S)	1.49E+00	4.29E-02
Carbonyl sulfide (COS)	1.87E+00	5.38E-02
Carbon disulfide (CS_2)	1.12E+00	3.22E-02
Formaldehyde	1.41E-02	4.06E-04
Hexane	3.38E-01	9.74E-03
Aluminum	1.34E-01	1.59E-02
Nickel	7.38E-03	4.56E-02
Vanadium	1.29E-01	1.60E-02

Note:

Emission rates for SO_2, NO_x, H_2S, COS, and CS_2 are from the PSD construction permit application for the C6 furnace group (RK & Associates, 2011).

Emission rates for formaldehyde and hexane are based on emission factors from AP-42, Vol. 1, CH 1.4: Natural Gas Combustion, Table 1.4-3, and maximum natural gas combustion rate from the PSD construction permit application for the C6 furnace group (RK & Associates, 2011).

Emission rates for metals are based on emission rates of coke and silicon carbide as modeled by RK & Associates combined with average mass fractions of aluminum, nickel, and vanadium in both coke and silicon carbide as measured by a materials analysis. Total emission rates for coke and silicon carbide were 0.429 and 2.133 tpy, respectively. Mass fractions of aluminum, nickel, and vanadium in coke are 5.80E-04, 1.72E-04, and 3.25E-04, respectively. Mass fractions in silicon carbide are 5.10E-04 (aluminum), 0 (nickel), and 5.40E-04 (vanadium).

Total sulfur dioxide emissions (including normal and malfunction emissions from both present existing facilities and proposed expansions) were utilized in the acid fog analysis, in order to obtain a conservative estimate of total pH reduction since background pH data sources were not considered fully representative and the pH calculation is non-linear. A value of 121.42 g/s was utilized for total (existing plus proposed) normal and malfunction sulfur dioxide emissions.

Figure 3-1: Modeled Gaseous and PM Maximum Receptor Locations around the WMH Facility

Maximum Impact Receptors

- Oxidizer Stack
- Gaseous 1-hr Max Conc
- Gaseous 3-hr Max Conc
- Gaseous 24-hr Max Conc
- Gaseous Annual Max Conc
- PM Annual Max Conc
- PM Annual Max Dry Dep
- PM Annual Max Wet Dep
- Receptors

0.4   0   0.4   0.8 Kilometers

	COMMENTS:		Gaseous and PM Maximum Modeling Receptor Locations		
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4.0   SHORT-TERM IMPACTS ASSESSMENT

This section includes an evaluation of any acute effects due to the proposed WMH expansion on phytotoxicity from incremental pollutant concentrations in air, and deposition of PM to vegetation leaf surface, which could affect photosynthesis. Additionally, SO_2 can dissolve in water droplets in the atmosphere and may create acid fog or acid mist, which could adversely affect vegetation growing in the vicinity of the WMH facility. Therefore, an acid fog analysis was also performed to evaluate any SO_2 impacts. The assessments in this section are updated from of the previous Endangered Species Evaluation report (2008) to reflect a current evaluation related to the planned addition of the sixth furnace, including emission increases associated with this planned addition and current conditions. Further background for these assessments was provided in the prior 2008 report. See detailed descriptions in Attachment A, Section 4.

4.1   Direct Phytotoxicity

Table 4-1 provides the worst-case estimation of incremental concentrations due to the proposed WMH facility expansion, as well as representative background levels, and benchmark concentrations for protecting the most sensitive vegetation. All short-term incremental concentrations are well below the most protective benchmarks, and tend to represent small fractions of background concentrations. Overall the modeling predicts no ecological harm or danger on direct phytotoxicity due to acute impacts from proposed WMH expansion, and the incremental pollutant concentrations are not expected to substantially change existing background air quality.

4.2   Particulate Deposition of Leaf Surfaces

AEROMOD was run with the PM_{10} emission rates reported above in Table 3-1. Predicted worst-case dry and wet particle deposition rates are 1.08 g/m²-yr (D_{dry}) and 0.42 g/m²-yr (D_{wet}), respectively. These values are used with Equation 1 to estimate the steady-state loading on plant surface (S_{plant}).

$$S_{plant} = \frac{D_{dry} + f_{wet} D_{wet}}{k_p}$$ (Equation 1)

U.S. EPA recommended values for coefficient $f_{wet} = 0.6$ (fraction of wet deposition remaining on the plant surface) and $k_p = 18$ yr⁻¹ (plant surface loss coefficient) are used. Equation 1 predicts particle loading of 0.074 g/m². This worst-case level is below the levels, 1-10 g/m², at which reduced photosynthesis have been observed. Therefore, no harm to endangered plants from particulate matter deposition is predicted.

Table 4-1 – Acute Modeled Increments and Comparison to Background and Benchmarks

Chemicals of Potential Concern	Averaging Time	Projected Incremental Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Ratio: Projected Increase to Background	Benchmark Concentration ($\mu g/m^3$) [E]
Sulfur dioxide (SO₂)	1 hour	25	100[A]	0.25	917
	3 hours	21	61[A]	0.34	786
	24 hours	4	22[B]	0.18	734[F]
Nitrogen oxides (NOx)	1 hour	2	130[C]	0.02	1880[G]
	3 hours	1.6	119[C]	0.01	1130[H]; 3760[I]
	24 hours	0.3	36[C]	0.01	564[J]; 75[K]
Hydrogen sulfide (H₂S)	3 hours	0.1	0.46[D]	0.22	28000[I]; 13941[L]

Note:

A -- Average level detected at three monitoring locations closest to the WMH facility. Data from Illinois EPA (2011), Illinois Annual Air Quality Report 2010, 1st highest samples in 2010 from Oglesby, Peoria and Joliet.

B -- Average level detected at three monitoring locations closest to the WMH facility. Data from Illinois EPA (2010), Illinois Annual Air Quality Report 2009, 1st highest samples in 2009 from Oglesby, Peoria and Joliet. 24-HR sulfur dioxide monitoring results are not available in the Illinois Annual Air Quality Report 2010.

C -- Derived from hourly NO_x data downloaded for the 2007 calendar year from the U.S. EPA's Air Quality System database (http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm). Braidwood, IL, in Will County, was selected as the closest available monitoring station to the WMH facility. The highest 1-hr NO_x concentration of 130 ug/m³ (0.069 ppm) was measured on June 11, 2007. The highest 3-hr NO_x concentration (running average) of 119 ug/m³ (0.063 ppm) was measured on June 11, 2007. The 24-hr maximum daily value of 36 ug/m³ (0.019 ppm) was measured on August 30, 2007. Hourly NO_x data for 2008, 2009 and 2010 calendar years from this monitoring site is not available.

D -- Upper bound estimated hydrogen sulfide ambient air concentration, from: Sciences International, Inc (1999), Toxicological profile for hydrogen sulfide, prepared for the U.S. Department of Health and Human Services.

E -- Source, unless otherwise noted: U.S. EPA (1980), A screening procedure for the impacts of air pollution sources on plants, soils, and animals. EPA 45C/2-81-078. Table 3.1, screening concentration values for most sensitive vegetation.

F -- Concentration to cause traces of leaf destruction over 24 hours calculated from: $(C - 0.24) t = 0.94$, t in hours, C in ppm (result: 0.28 ppm, 734 $\mu g/m^3$). Equation is from World Health Organization (1961), Air Pollution, Effects of air pollution on plants, MD Thomas. WHO Monograph Series No. 46, p. 239.

G -- Lowest available NOAEL for animals (mice, guinea pigs and rats) of 1 ppm (1880 µg/m^3) for 1 hour exposure period, from: Toxico-Lofic Consulting, Inc (2007), Assessment Report on Nitrogen Dioxide for Developing Ambient Air Quality Objectives, prepared for Alberta Environment, p. 24

H -- Lowest available NOAEL for animals (rats) of 0.6 ppm (1130 µg/m^3) for 3 hour exposure period, from: Toxico-Lofic Consulting, Inc (2007), Assessment Report on Nitrogen Dioxide for Developing Ambient Air Quality Objectives, prepared for Alberta Environment, p. 24

I -- Screening concentration is for 4 hour averaging time as more conservative proxy.

J -- Screening concentration is for 1 month averaging time as more conservative proxy.

K -- Critical level from WHO Air quality guidelines for Europe, Second edition, p. 232.

L -- Lowest available NOAEL for animals (Fischer-344 Rat) of 10 ppm, from p. 17 of the toxicological profile for hydrogen sulfide.

4.3   Acid Fog Analysis

4.3.1 Fog History

Hourly surface data from January 1, 2006 through December 31, 2010 from the Peoria airport was obtained from the National Climatic Data Center (NCDC) (http://www.ncdc.noaa.gov/oa/mpp/digitalfiles.html#DIG).

Figure 4-1, 4-2 and 4-3 summarize the climatology of fog and mist based on the 5-year surface hourly data from the Peoria Airport station. As seen from these figures, most fog and mist events occur in the winter, particularly in December. During growing season (May – September), the frequency of fog and mist is relatively low. The majority of fog and mist events last only one hour and the average duration is no more than 10 hours, but some events can last to 16 hours.

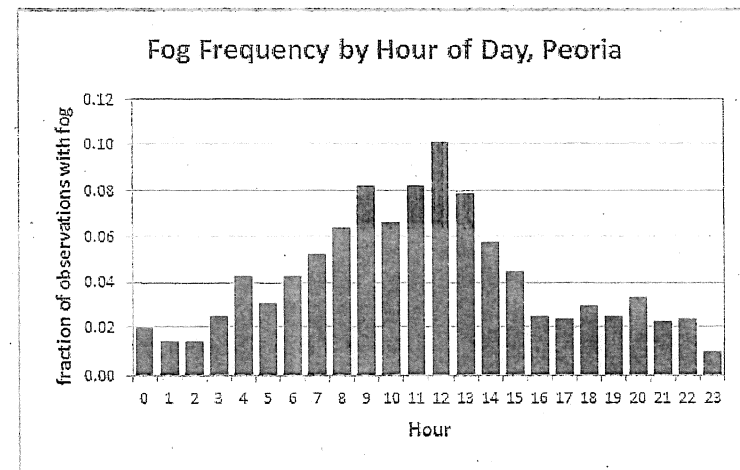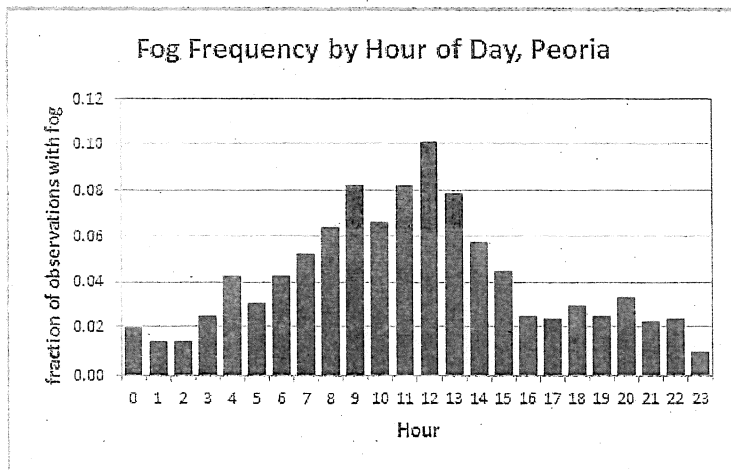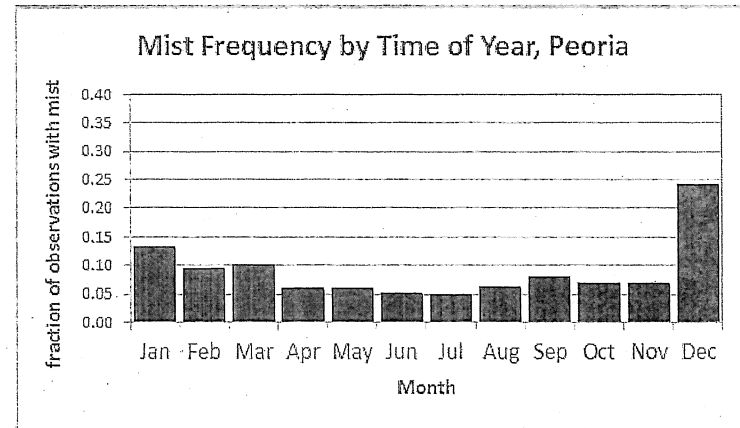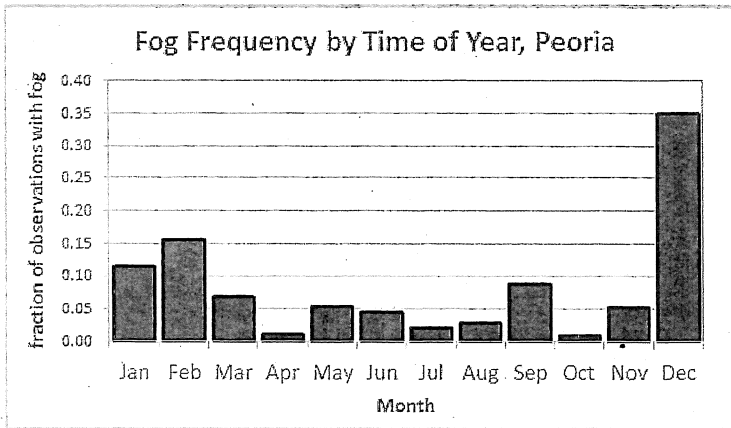### 4.3.2 SO_2 Impacts during Fog

A maximum impact receptor for 1-hour concentrations from the SO_2 AERMOD modeling was selected as the receptor of interest for the acid fog analysis. Besides the highest receptors along the WMH fence line, one comparatively high impact receptor was located about 560 meters away from the stack source and within a patch of potential endangered species habitat, see Figure 4-4. Coordinates of this receptor are: Easting 307400 m, Northing 4574100 m.

For this receptor, an AERMOD modeling was run to produce hourly time series of SO_2 concentrations for the 2006-2010 period based on total WMH facility emissions, including existing and proposed facilities under normal and malfunctions. The time series was filtered by co-occurrence with fog or mist during the growing season. Figure 4-5 displays the resulting distributions of SO_2 concentrations during fog/mist events. Over 90% of the hourly SO_2 data are of negligible magnitude (<5 $\mu g/m^3$). Some modeled events predict higher results, but still well below the most protective screening-level concentrations (917 $\mu g/m^3$, 1-hr SO_2 benchmark for the most sensitive vegetation, Table 4-1).

In Section 4.3.3, an acid fog model is used to analyze how the SO_2 could affect fog or mist pH.

Figure 4-1 Fog and Mist Frequency by Time of Year and Time of Day, from Peoria Airport Observations, 2006-2010

Fog Frequency by Time of Year, Peoria

Mist Frequency by Time of Year, Peoria

Fog Frequency by Hour of Day, Peoria

Fog Frequency by Hour of Day, Peoria

16

Figure 4-2 Frequency of Fog and Mist by Time of Day during the Growing Season (May – September), from Peoria Airport Observations, 2006-2010

Growing Season Mist Frequency by Hour of Day, Peoria
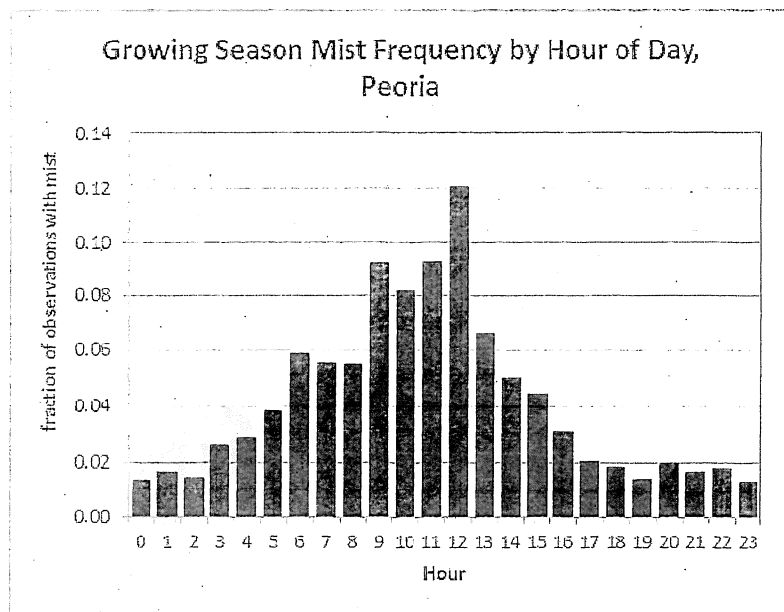

Growing Season Fog Frequency by Hour of Day, Peoria
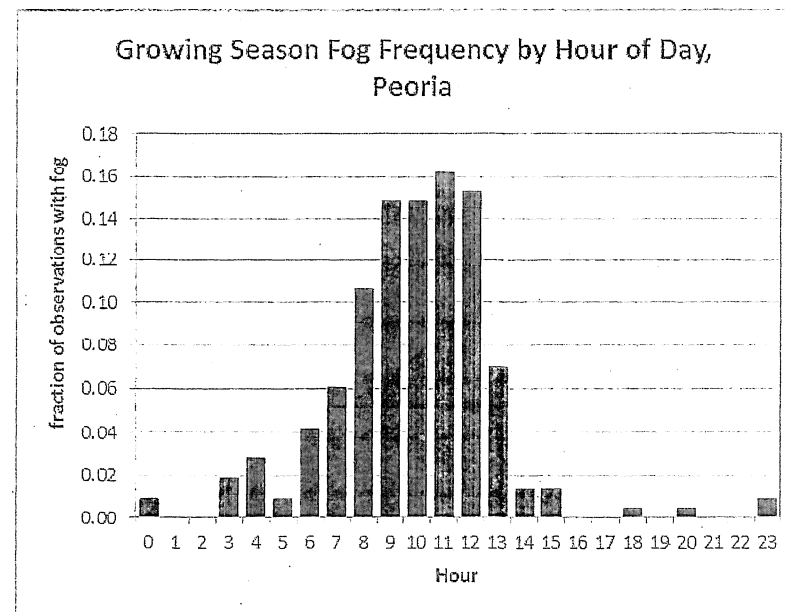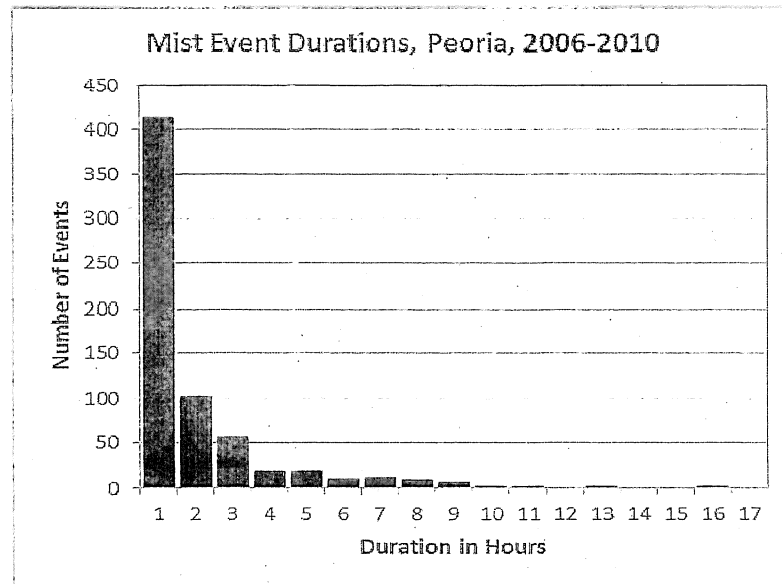
Figure 4-3 Fog and Mist Event Durations, Growing Season Only, from Peoria Airport Observations, 2006-2010

Fog Event Durations, Peoria, 2006-2010

Mist Event Durations, Peoria, 2006-2010
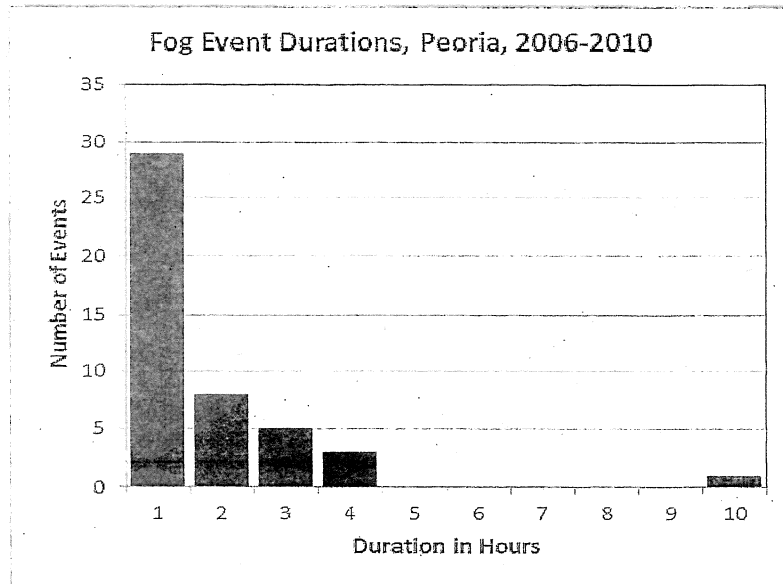
Figure 4-4: Selection of the Maximum Impact Ecological Receptor to Use for Acid Fog Analysis

AERMOD 1-Hour Maximum SO_2 Concentrations

Thermal Oxidizer

Maximum Impact Ecological Receptor

560 m

0.2   0   0.2   0.4 Kilometers

	COMMENTS:		Selection of the Maximum Impact Receptor for Acid Fog Analysis		
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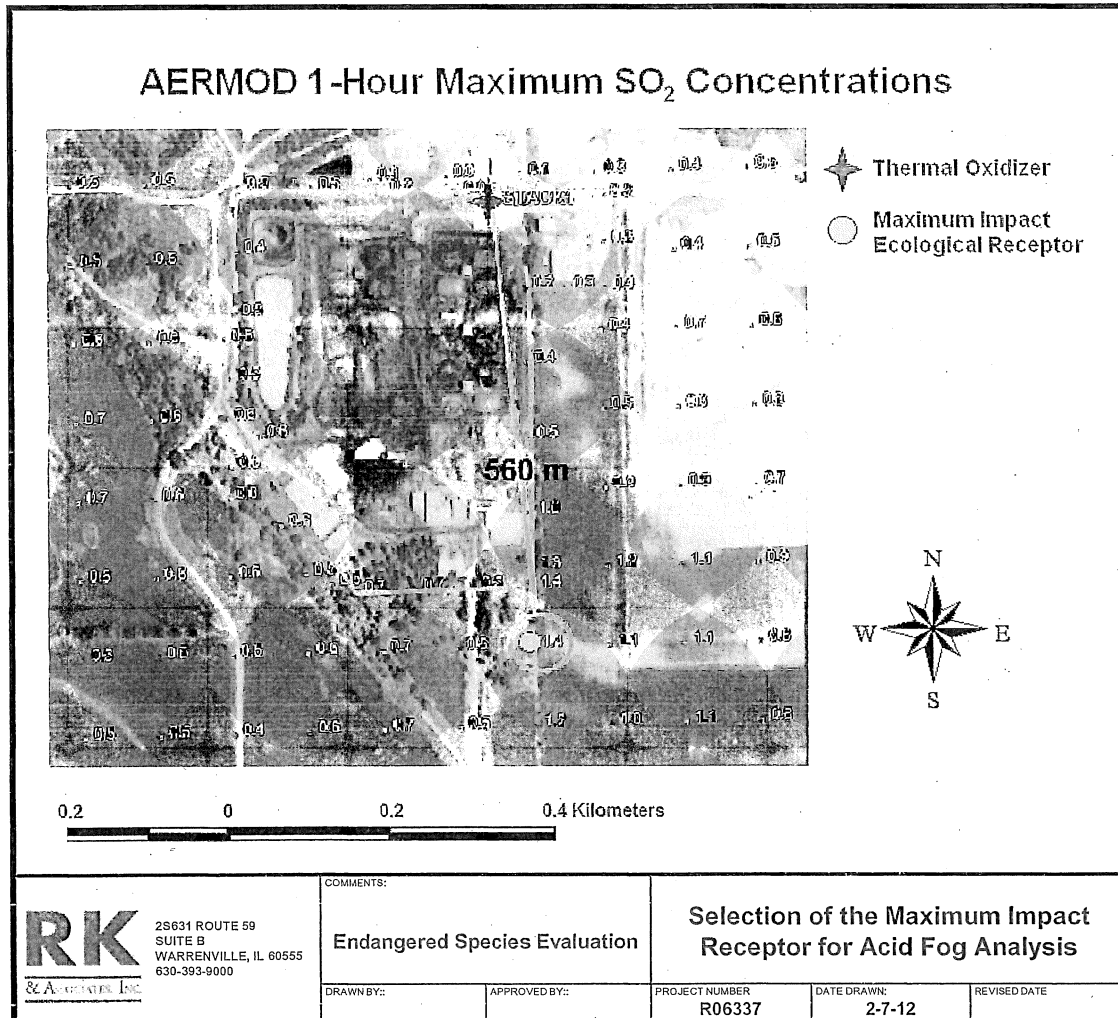
Figure 4-5 Upper Quartile Hourly SO₂ Concentrations during Fog and Mist at Selected High-Impact Ecological Receptor, as Modeled by AERMOD with Total WMH Emissions (Including Present Emissions as well as Emissions due to Proposed Expansion under Normal and Malfunction Hours)

SO₂ Concentrations during Fog (from Total Emissions including Malfunction)

SO₂ Concentrations during Mist (from Total Emissions including Malfunction)

20
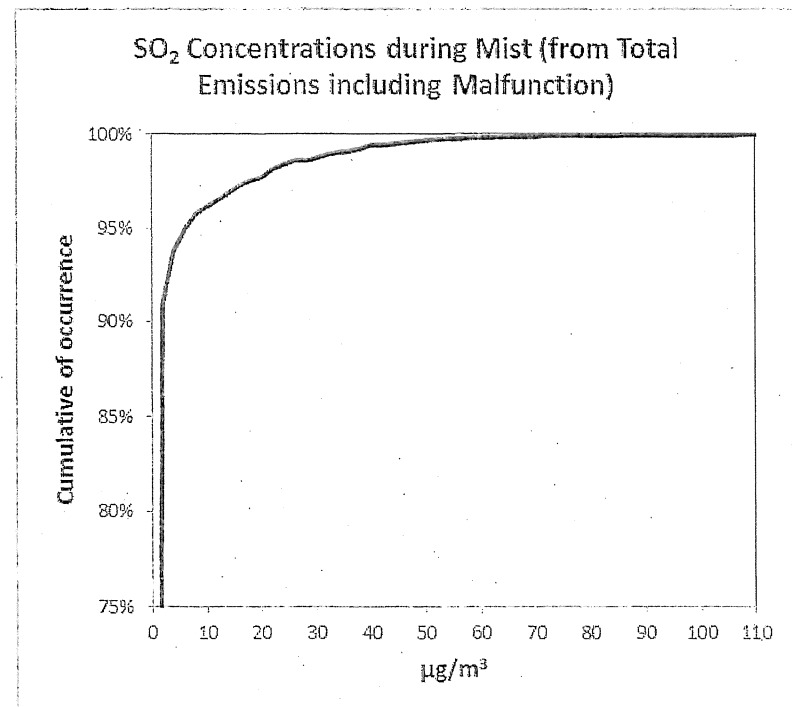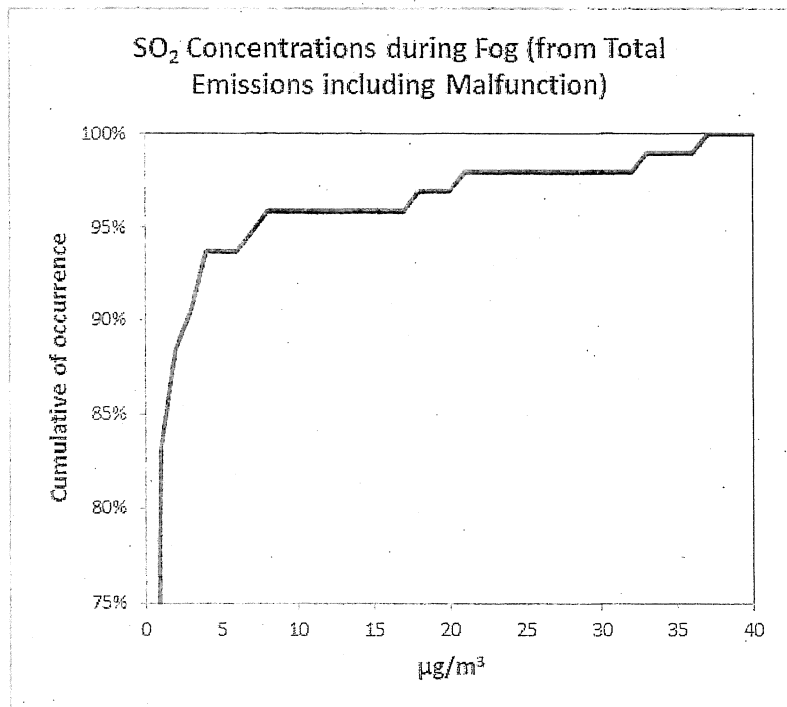
4.3.3 The Acid Fog Model

The SO_2 converts to $[SO_4^=]$ according to a linear conversion rate, with a first-order approximation given by:

$$[SO_4^=] = (1 - e^{-kt}) \cdot [SO_2] = (1 - e^{-k_{con}\frac{d}{u}}) \cdot [SO_2] \qquad \text{(Equation 2)}$$

where the terms are:

$[SO_4^=]$	Concentration of $SO_4^=$ in aqueous solution, mol/l;
k_{con}	Conversion rate of the SO_2 gas to aqueous, ionized $SO_4^=$ (1/s);
t	Pollutant residence time in the atmosphere (s);
d	Distance of travel from the emission source (m); and
u	Wind speed (m/s).

The maximum impact ecological receptor is 560 meters away from the stack, $d = 560$m. k_{con} is 10%/hr (2.78E-05/s). Detailed discussion of k_{con} is shown in Attachment A, Section 4.2.5. Wind speed data was extracted from the surface hourly data (2006-2010, Peoria Airport station) obtained from the National Climatic Data Center (NCDC). The resolution of the wind speed anemometer at the Peoria Airport station is 2 knots (about 1 m/s). However, due to the mechanical resistance of the instrument, wind speed in the 0-3 m/s range is seldom detected, thus recorded as 0. When submitting wind speed values to the acid fog model (Equation 2), all 0 data were conservatively replaced with 1.5 m/s, which is half of the anemometer detection limit.

Fog or mist pH_{post} from the $[SO_4^=]$ due to total WMH SO_2 emissions is calculated using the following model:

$$pH_{post} = -\log_{10} \left\{ 2 \cdot [SO_4^=] + 10^{-pH_{pre}} \right\} \qquad \text{(Equation 3)}$$

To calculate pH_{post}, a background pH_{pre} must be known (see next section for the background pH).

4.3.4 Background pH Determination

The weekly precipitation pH data (2006 – 2010), which can be taken as background pH level for clouds in the region, was obtained from the National Atmospheric Deposition Program (NADP) from the Bondville station (http://nadp.sws.uiuc.edu/nadpdata/weeklyRequest.asp?site=IL11). The average weekly lab-measured pH between the years 2006-2010 was 5.0 at the Bondville station. The lowest weekly pH was 4.0 over the same period; this value was used in the acid fog model as pH_{pre}.

Data from the 5-year record of weekly precipitation pH observations at Bondville were summarized in Figure 4-6 and Figure 4-7. Extreme high or low pH values tend to occur with extremely low precipitation, such as might occur via fog or mist, although most weeks of low precipitation do not have extreme pH.

4.3.5 Sulfur Dioxide to Sulfate Conversion

The SO_2 [S(IV)] to $SO_4^=$, [S(VI)] oxidation process is simplified by the assumption that all SO_2 gas is absorbed into the liquid water of the fog or mist. Fog is assumed to have a liquid water content of 0.1 g/m^3, and mist is assumed to have a liquid water content of 0.01 g/m^3. Resulting $SO_4^=$ concentrations in liquid water of fog or mist are shown in Figure 4-8.

4.3.6 Worst-Case Modeled Acid Fog pH

An AERMOD run produced hourly SO_2 concentrations from total WMH facility emissions (existing plus expansion, including malfunction hours), which are considered to contribute to the worst-case fog/mist pH. The fog/mist pH was calculated using Equation 2 and Equation 3.

Figure 4-9 shows the distribution of pH values attained during fog/mist events in 2006-2010. Co-occurrence of pH values attained with event durations are shown in Figure 4-10. Over the entire 5-year modeling period, the lowest modeled pH value is 2.8, which is higher than the benchmark pH 2.6 (see Attachment A, Section 4.2.6 for descriptions of the benchmark pH value). Overall, the acid fog analysis concludes that the proposed WMH expansion will not have potential to degrade endangered species habitat.

Figure 4-6 The Distribution of Weekly pH Values Attained Over the 5-Year Modeling Period at the Bondville Background Monitoring Site. Minimum: 4.0, Mean: 5.0

Weekly Lab-Measured pH, Bondville, 2006-2010
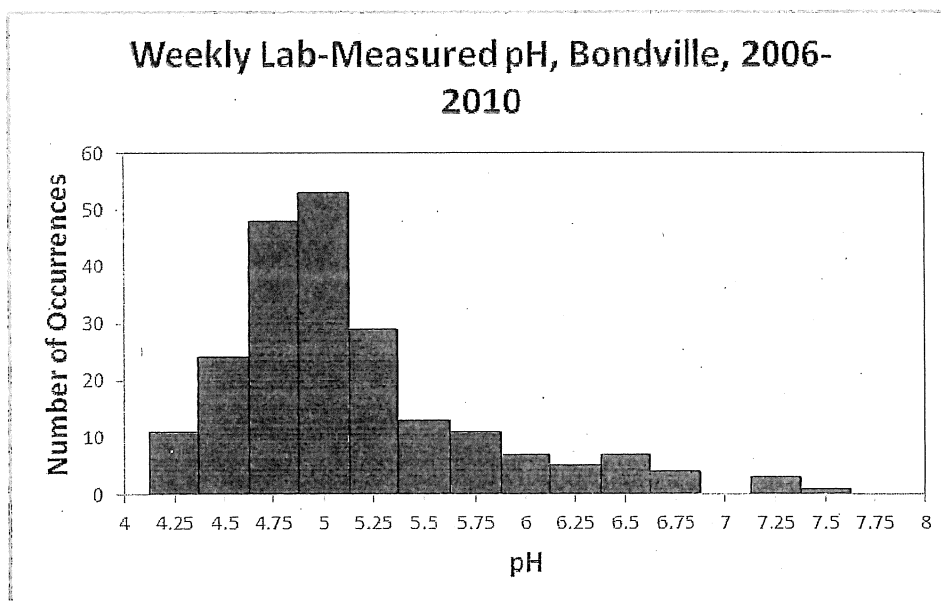
Figure 4-7 Scatterplot of Co-Occurrence of Weekly pH with Weekly Precipitation

Weekly Lab-Measured pH versus Precipitation, Bondville, 2006-2010
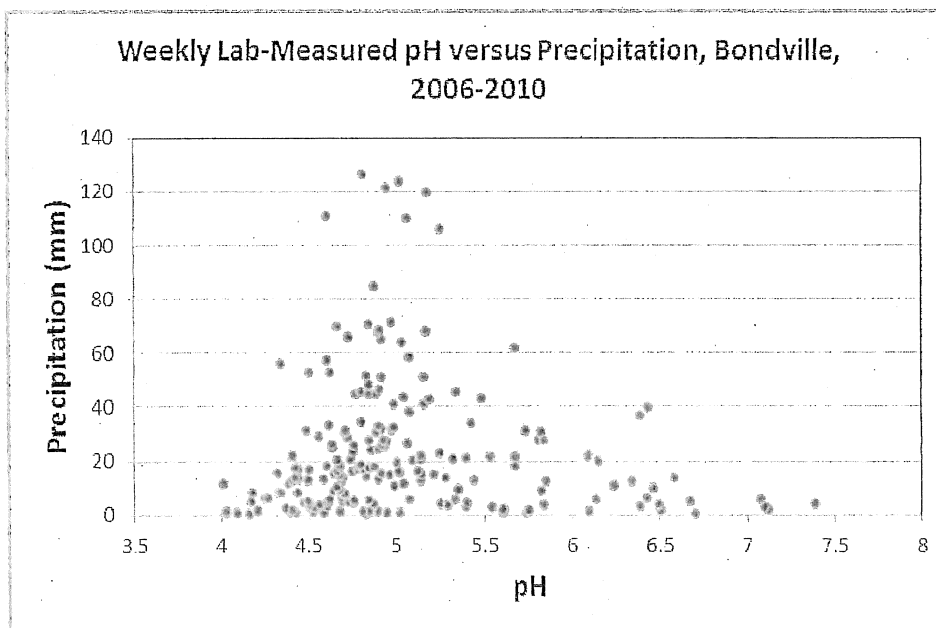
Figure 4-8 Acid Fog Model Results: Distribution of SO$_4$ Concentrations in Fog and Mist Water, from SO$_2$ Conversion Rate of 10%/hr. Note Semi-Log Scale on X-Axis
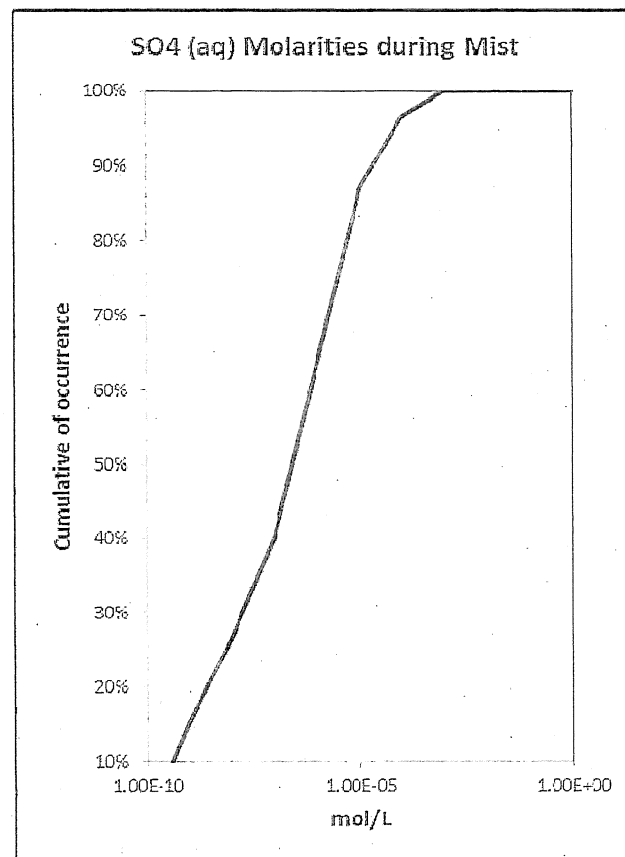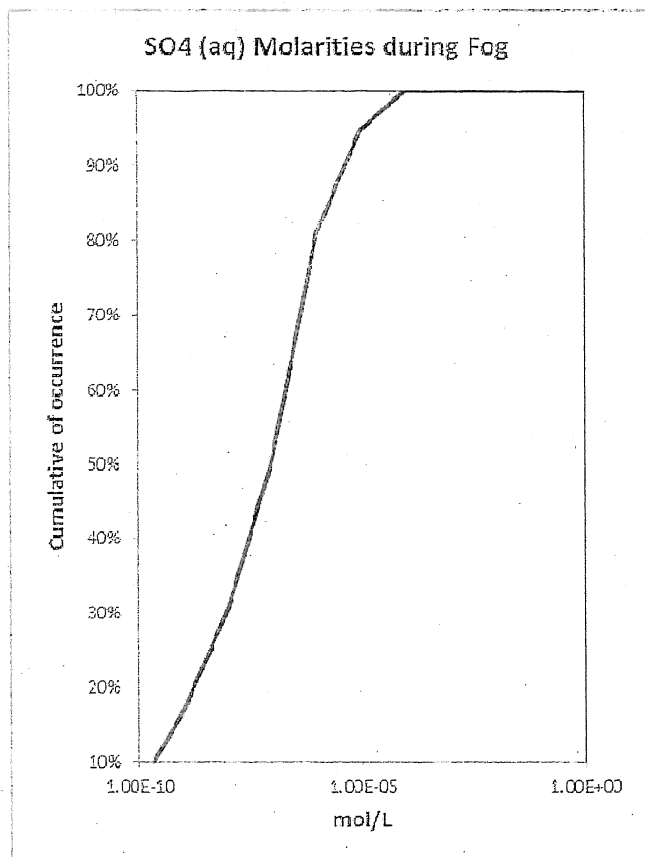
Figure 4-9 Acid for Model Results: Distributions of Event-Averaged pH for All Fog or Mist Events 2006-2010 and of Their Durations, from Starting pH = 4.0 and SO_2 Conversion Rate of 10%/hr

25
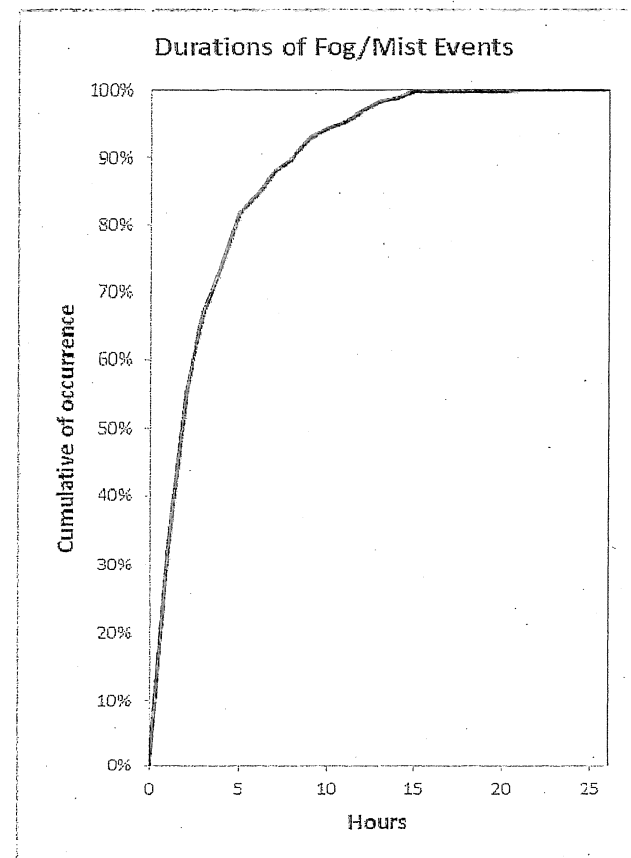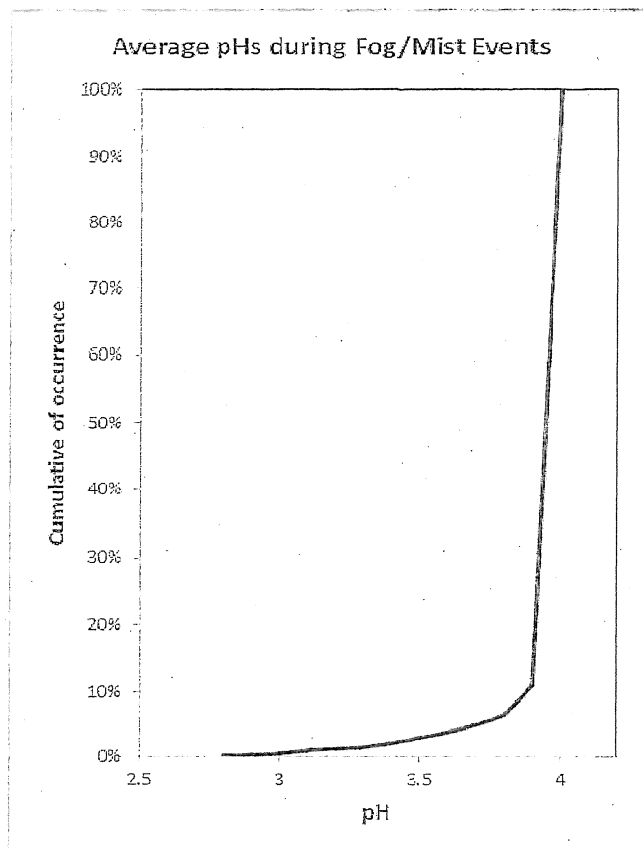
Figure 4-10 Acid Fog Model Results: Scatterplot of Event-Average pH and
Fog/Mist Event Duration for All Events 2006-2010, from Srting pH = 4.0 and SO$_2$
Conversion Rate of 10%/hr

Fog/Mist Event Average pH by Event Duration
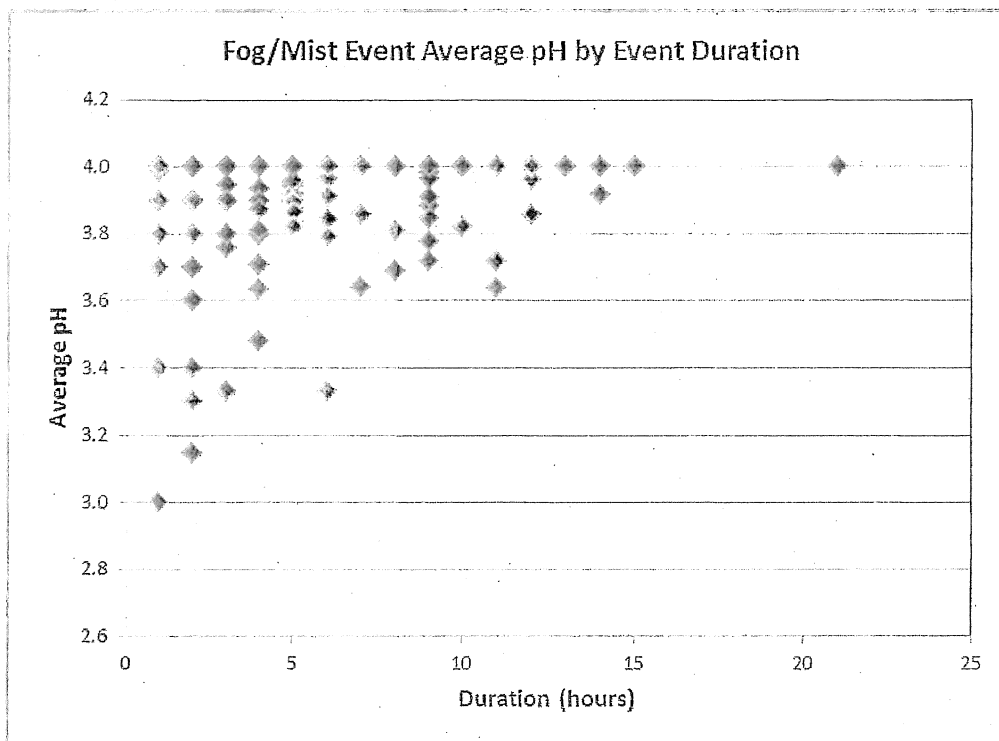
5.0 LONG-TERM IMPACTS ASSESSMENT

This section evaluates three types of potential long-term impacts to threatened and endangered species: chronic toxicity due to incremental concentrations of pollutants in the atmosphere, accumulation of metals in soil, surface water and sediment, and food chain effects via bioaccumulation of metals to the Indiana bat.

5.1 Chronic Effects

The annually averaged atmospheric concentrations for pollutants of interest are summarized in Table 5-1 based on the incremental emissions due to the proposed WMH expansion. Most projected pollutant increases are shown to have very low incremental accumulations relative to background concentrations (less than 10%), indicating no appreciable increase over the background. In the case of vanadium, although the modeled incremental concentration accounts for 53% of the background concentration, it is well below the chronic exposure limit 20 $\mu g/m^3$ in the air (LOAEL of vanadium based on chronic upper respiratory tract symptoms) suggested by WHO.

5.1.1 Soil Modeling and Comparisons

The HAP deposition rates in soil are estimated using a simple mixing model described as the Equation 4. Detailed assumption and description of the model are displayed in Attachment A Section 5.2.1.

$$C_{HAPsoil} = \frac{D_{HAP}T_{Exo}}{d_{soil}\rho_{soil}}$$

(Equation 4)

Where

$C_{HAPsoil}$	Concentration, or mass fraction, of the HAP in soil (mg/kg);
D_{HAP}	HAP deposition rate estimated by air dispersion/deposition modeling (mg/m²/yr);
T_{Exo}	Years of operation of the proposed WMH modifications, 100 years;
d_{soil}	Depth of the shallow soil layer (m), 2 cm (0.02 m); and
ρ_{soil}	Bulk density of soil (kg/m³), 1500 kg/m³.

Table 5-2 summarizes modeled worst-case concentrations in soil along with representative background concentrations and relevant benchmarks. All pollutants are shown to have low incremental accumulations relative to background soil concentrations (a few percent at most). In the case of vanadium, the background soil concentration (generic for all rural counties in Illinois) exceeds the Region 5 ESL benchmark substantially. However, the contribution of predicted impacts from the proposed WMH expansion is not significant relative to background levels, and the benchmark for the Indiana bat (mammals) is not approached.

Table 5-1 – Chronic Concentrations of All Chemicals of Concern relative to Background

Chemicals of Potential Concern	Incremental Emission Rate (tons/year)	Projected Incremental Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$) [A]	Ratio: Projected Increase to Background
Hydrogen sulfide (H_2S)	1.49	5.55E-04	1.65E-01 [B]	0.003
Carbonyl sulfide (COS)	1.87	6.96E-04	1.21E+00 [C]	0.0006
Carbon disulfide (CS_2)	1.12	4.17E-04	8.87E-02	0.005
Sulfur dioxide (SO_2)	507.38	1.89E-01	2.82E+00 [G]	0.067
Nitrogen oxides (NOx)	39.58	1.47E-02	1.07E+01 [H]	0.001
Formaldehyde	0.01	5.25E-06	2.99E-01	0.00002
Hexane	0.34	1.26E-04	5.07E-02	0.002
Aluminum (Al) [F]	0.13	9.64E-04	3.83E-02 [D,E]	0.025
Nickel (Ni) [F]	0.01	7.59E-05	1.10E-03 [D,E]	0.069
Vanadium (V) [F]	0.13	8.63E-04	1.63E-03 [D,E]	0.53

Notes:

A -- Modeled background estimate from the U.S. EPA's 1999 National Air Toxic Assessment for the census tract in which WMH is located, unless otherwise specified. Data available at: http://www.epa.gov/ttn/atw/nata1999/tables.html

B -- Ambient air concentrations of hydrogen sulfide from natural sources range between 0.11 and 0.33 ppb (0.165 – 0.495 $\mu g/m^3$) in the United States. From: U.S. Department of Health and Human Services, Public Health Service Agency for Toxic Substances and Disease Registry (2006), Toxicological Profile for Hydrogen Sulfide, p. 9.

C -- Average level detected from submonthly ground-level ambient air measurements at Niwot Ridge, CO, between 2000 and 2007. Level agrees with Northern Hemisphere average to one significant figure (494 ppt at Niwot Ridge vs. 476 ppt over NH). Source: Montzka et al, 2007.

D -- Average levels detected at five monitoring locations in Illinois in 2010, based on chemical speciation analyses of $PM_{2.5}$ measurements. Concentrations varied by less than a factor of two across locations. Ranges of 0.029–0.046 $\mu g/m^3$, 0.0007–0.0015 $\mu g/m^3$, and 0.0009–0.0019 $\mu g/m^3$, were measured for Al, Ni, and V, respectively.

E -- Data obtained from the U.S. EPA's Air Quality System (AQS) http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm (Last accessed on Feb 01, 2012).

F -- Incremental emission rates are based on the sum of particulate contributions from coke- and silicon carbide-related sources. The fractions of metals in the sources are based on measured compositions of coke and silicon carbide product (SCP). Coke contains average Al, Ni, and V mass fractions of 0.0006, 0.0002, and 0.0003, respectively. SCP contains an average mass fraction of 0.0005 of both Al and V.

G -- Annual mean from Illinois EPA (2010), Illinois Annual Air Quality Report 2009, Oglesby.

H -- An average concentration of 0.0056 ppm (10.7 ug/m^3) of NOx was measured at Braidwood, IL over the period from April 17, 2007 to September 30, 2007 (3619 hourly observations). Data downloaded from the U.S. EPA's Air Quality System database (http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm).

Table 5-2 – Soil Accumulation of Metals and Comparison to Background

Chemicals of Potential Concern	Projected Deposition Rate (g/m^2/yr) [A]	Projected Soil Loading (mg/kg)	Background Concentration in Soil (mg/kg) [B]	Ratio: Projected Increase to Background	Ecological Benchmark Concentration (mg/kg) [C]
Aluminum (Al)	4.77E-04	1.59E+00	9200	1.73E-04	n/a [D]
Nickel (Ni)	1.59E-05	5.28E-02	13	4.06E-03	38 (plants); 130 (mammals)
Vanadium (V)	4.78E-04	1.59E+00	25	6.38E-02	1.59 [E] (plants); 280 (mammals)

Note:

A -- Incremental emission rates are based on the sum of particulate contributions from coke- and silicon carbide-related sources. The fractions of metals in the sources are based on measured compositions of coke and silicon carbide product (SCP). Coke contains average Al, Ni, and V mass fractions of 0.0006, 0.0002, and 0.0003, respectively. SCP contains an average mass fraction of 0.0005 of both Al and V.

B -- Data provided by the Illinois Administrative Code, Title 35, Part 742, Table G, "Concentrations of Inorganic Chemicals in Background Soils." Values are for counties outside Metropolitan Statistical Areas http://www.ilga.gov/commission/jcar/admincode/035/03500742ZZ9996agR.html (last accessed Feb 1, 2012).

C -- Source, unless otherwise noted: U.S. EPA, Ecological Soil Screening Levels http://www.epa.gov/ecotox/ecossl/ (last accessed Feb 1, 2012).

D -- As per the discussion in the U.S. EPA Eco-SSL document for Aluminum, no number is cited because aluminum toxicity in soil is not based on total aluminum concentration, but rather on soil pH. See further discussion in Attachment A Section 5.2.4.

E -- Since no vanadium Eco-SSL for plants is available, the value from EPA, Region 5, RCRA Ecological Screening Levels is used, http://www.epa.gov/Region5//waste/cars/pdfs/ecological-screening-levels-200308.pdf (last accessed Feb 1, 2012). This value was found to be lowest ecological benchmark available for soil on the ORNL Risk Assessment Information System (http://rais.ornl.gov/tools/eco_search.php).

5.1.2 Surface Water Modeling and Comparison

The worst-case screening-level concentrations in water are estimated with the incremental emission rates for all pollutants of interest (Table 5-3). Results show that pollutant concentrations will be very small fractions of the background concentrations in surface water. Background concentrations of the three metals are based on 22 years (1977 to 1999) of historical IEPA measurements of the Illinois River at Hennepin, and represent average of 134 (Al), 149 (Ni), or 151(V) samples. In the case of aluminum, the background level significantly exceeds the benchmark found for the most sensitive species; however, impacts resulting from proposed WMH modifications are predicted to not contribute significantly.

5.1.3 Sediment Modeling and Comparison

Projected sediment loading increments due to proposed WMH expansion are estimated based on the incremental emission rates for all pollutants of concern. Results are shown in Table 5-4. The sediment analysis shows that pollutant loading to sediments will be very small fractions (<<0.01%) of background concentrations in sediments. For nickel, the background level exceeds benchmark, but as in the surface water case, this cannot be attributed to effects of the facility since only miniscule increments are predicted for proposed WMH modifications. No background or benchmark was found for vanadium.

5.2 Food Chain Analysis for Indiana Bat

Food chain analysis for the proposed WMH expansion of a sixth furnace is similar to the previous analysis for the fifth furnace (see Attachment A, Section 5.2.4). Aluminum deposition will not affect food chain for the Indiana bat.

For Nickel, the ecological screening level for mammals is 130 mg/kg dry weight in soil. The background level of Nickel in soil in this region is only 13 mg/kg, and the incremental emissions due to the WMH expansion will only cause the background increments by a factor of 0.004. Incremental loadings of Nickel to surface water and sediment are also very small fractions of background levels. Therefore, no food chain impact is expected for Nickel.

For Vanadium, the ecological screening level for mammals is 280 mg/kg dry weight, which is more than a factor of 10 over background. The WMH expansion only causes increments at a factor of 0.06 over background. Therefore, no food chain impacts are expected for Vanadium.

Table 5-3 – Surface water accumulation of metals and comparison to background

Chemicals of Potential Concern	Projected Surface Water Loading (μg/l)	Background Concentration in Surface Water (μg/l) [A]	Ratio: Projected Increase to Background	Ecological Benchmark for Surface Water (μg/l) [B]
Aluminum (Al) [F]	3.58E-02	939	3.83E-05	75 [C]
Nickel (Ni) [F]	1.03E-03	13	7.91E-05	28.9
Vanadium (V) [F]	3.61E-02	5	7.23E-03	12

Notes:

A -- Average of total concentration data collected by Illinois EPA at the surface water station "Illinois River at Hennepin." Data downloaded from EPA STORET Legacy Data Center, http://www.epa.gov/storpubl/legacy/gateway.htm (last accessed Feb 1, 2012).

B -- Source, unless otherwise noted: U.S. EPA Region 5, RCRA Ecological Screening Levels (ESLs) for surface water, http://www.epa.gov/Region5//waste/cars/pdfs/ecological-screening-levels-200308.pdf (last accessed Feb 1, 2012).

C -- No benchmark was available from Region 5 ESLs for surface water. 0.075 mg/L (EC20 Sensitive Species Surface Water Screening Benchmark) was the lowest benchmark available on ORNL RAIS. Reference: Suter, GW (1996), II. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxic. Chem. 15:1232-1241.

Table 5-4 – Sediment Accumulation of Metals and Comparison to Background

Chemicals of Potential Concern	Projected Sediment Loading (µg/kg)	Background Concentration in Sediment (µg/kg) [A]	Ratio: Projected Increase to Background	Ecological Benchmark for Sediment (µg/kg)
Aluminum (Al)	7.46E+01	5.30E+07	1.41E-06	7.32E+07 [B]
Nickel (Ni)	2.14E+00	3.30E+04	6.50E-05	2.27E+04 [C]
Vanadium (V)	7.54E+01	n/a	n/a	n/a [D]

Notes:

A -- Median (Percentile 50) element concentration for high-order streams taken from Colman, JA and RF Sanzolone (1992), Geochemical characterization of streambed sediment in the Upper Illinois River Basin. Water Resources Bulletin 28(5), 933-950.

B -- No sediment benchmarks for aluminum were available from Region 5 ESLs. Value cited is the lowest available ecological benchmark on ORNL RAIS for aluminum in sediment: ARCS NEC Sediment Screening Benchmark, 73200 mg/kg. Reference: U.S. EPA (1996), Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008.

C -- Source: U.S. EPA Region 5, RCRA Ecological Screening Levels (ESLs) for sediment, http://www.epa.gov/Region5//waste/cars/pdfs/ecological-screening-levels-200308.pdf

D -- There are no sediment benchmarks for vanadium on ORNL RAIS.

6.0 CONCLUSIONS

The Ecological Screening Evaluation concludes that the proposed expansion of the WMH facility has very little likelihood to cause adverse effects on threatened and endangered species.

From the acute and chronic effect analyses, short-term and long-term increments of pollutant concentrations in the air due to the proposed WMH expansion will be only small fractions of existing background levels, and are not expected to adversely affect plant species either by direct phytotoxicity or by more subtle changes that might influence the structure of plant communities.

An acid fog analysis was performed to assess the potential damage on endangered plant species by incremental sulfur dioxide emissions that might produce low-pH fog or mist. Starting with the lowest background pH measured in this region (pH = 4.0), the magnitude and frequency of potential low-pH fog-water exacerbations by WMH emissions were predicted with dispersion modeling combined with occurrence of fog/mist events. Over a five-year simulation period, no "worst-case" hourly pH value was predicted to exceed the estimated benchmark level of 2.6 that would be necessary to cause damage to vegetation.

In addition, deposition of metals to soil, surface water, and sediment were also considered. Analysis shows that incremental loadings of the three metals (Aluminum, Nickel and vanadium) are at small fractions of existing background levels, and all of the modeled impacts are also smaller than screening-level ecological benchmarks. Additional food chain analysis indicates that incremental pollutant emissions from the WMH facility are not likely to bio accumulate in the environment or lead to greater exposure levels in the diets of higher trophic species, such as the Indiana bat.

In summary, the proposed increases in emissions from the WMH facility due to the proposed expansion are not expected to adversely impact threatened and endangered species in the area.

7.0 LITERATURE REVIEW

Related literature search and results have been summarized in the previous Endangered Species Evaluation (2008); see Attachment A, Appendix A. In this section, only additional literature related to this report is listed.

Illinois Endangered Species Protection Board (2011), Checklist of Endangered and Threatened Animals and Plants of Illinois http://www.dnr.state.il.us/ESPB/pdf/2011_Checklist.pdf (last accessed Feb 7, 2012)

Montzka, S.A., P. Calvert, B.D.Hall, J.W.Elkins, T.J.Conway, P.P.Tans and C.Sweeney (2007) On the Global Distribution, Seasonality, and Budget of Atmospheric Carbonyl Sulfide (COS) and Some Similarities to CO_2, Journal of Geophysical Research, Vol. 112, D09302, doi: 10.1029/2006JD007665.

Toxico-Logic Consulting Inc. (2007), prepared for Alberta Environment, Assessment Report on Nitrogen Dioxide for Developing Ambient Air Quality Objectives.

U.S. Department of Health and Human Services Public Health Service Agency for Toxic Substances and Disease Registry (2006), Toxicological Profile for Hydrogen Sulfide.

World Health Organization Regional Office for Europe Copenhagen (2000), Air Quality Guidelines for Europe, Second Edition, WHO Regional Publications, European Series, No. 91.

RK
& Associates, Inc.

ATTACHMENT A

WASHINGTON MILLS HENNEPIN, INC.

ENDANGERED SPECIES EVALUATION

(2008)

Washington Mills Hennepin, Inc.
Endangered Species Evaluation

Submitted to:
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January 8, 2008

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Contents

Tables

Figures

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1. Introduction

Washington Mills Hennepin, Inc. (known as Exolon Company prior to January 1, 2008; hereafter referred to as "WMH") produces silicon carbide (SiC) at a facility in Hennepin, Illinois along the banks of the Illinois River in Putnam County. See Figure 1 for a map of the WMH facility and its surrounding environs. WMH is one of the largest producers of high grade SiC in the world and the only producer in the United States. In order to supply increased demand for high grade SiC, WMH proposes to expand the facility to allow for increased high grade SiC production. Proposed changes involve the addition of a fifth furnace, which would increase emissions. U.S. EPA Region 5 requested an evaluation of potential impacts of the proposed WMH expansion to threatened or endangered species populations or their critical habitats in order to inform decision points in Section 7 of the Endangered Species Act. In particular, an evaluation of potential acid fog effects on plants was suggested. This report fulfills the EPA request and determines whether the proposed expansion to the WMH facility could adversely affect federally listed species, directly or indirectly. Federally listed species of concern are the Indiana bat (*Myotis sodalis*), eastern prairie fringed orchid (*Plantanthera leucophaea*), prairie bush clover (*Lespedeza leptostachya*), and decurrent false aster (*Bolotonia decurrens*).

The endangered species evaluation begins with an analysis of the biology, recovery plans, and preferred habitats of the listed species, in particular the potential for populations to exist in the vicinity of WMH. The emissions resulting from WMH expansion and their fate and transport are then discussed, and the modeling setup and modeled maximum impact sites described. Potential short-term effects, including acute toxicity and the potential for acid fog, are assessed, followed by potential long-term effects, including chronic toxicity, accumulation of metals in soils and sediment, and bioaccumulation in Indiana bat populations. Finally, conclusions are drawn as to the overall potential for detrimental impacts of the proposed WMH expansion on federally listed species. A literature review was conducted and is presented in an annotated bibliography of potentially relevant results in an Appendix. Another Appendix contains details of the AERMOD modeling setup for acid fog analysis and particulate matter analysis.
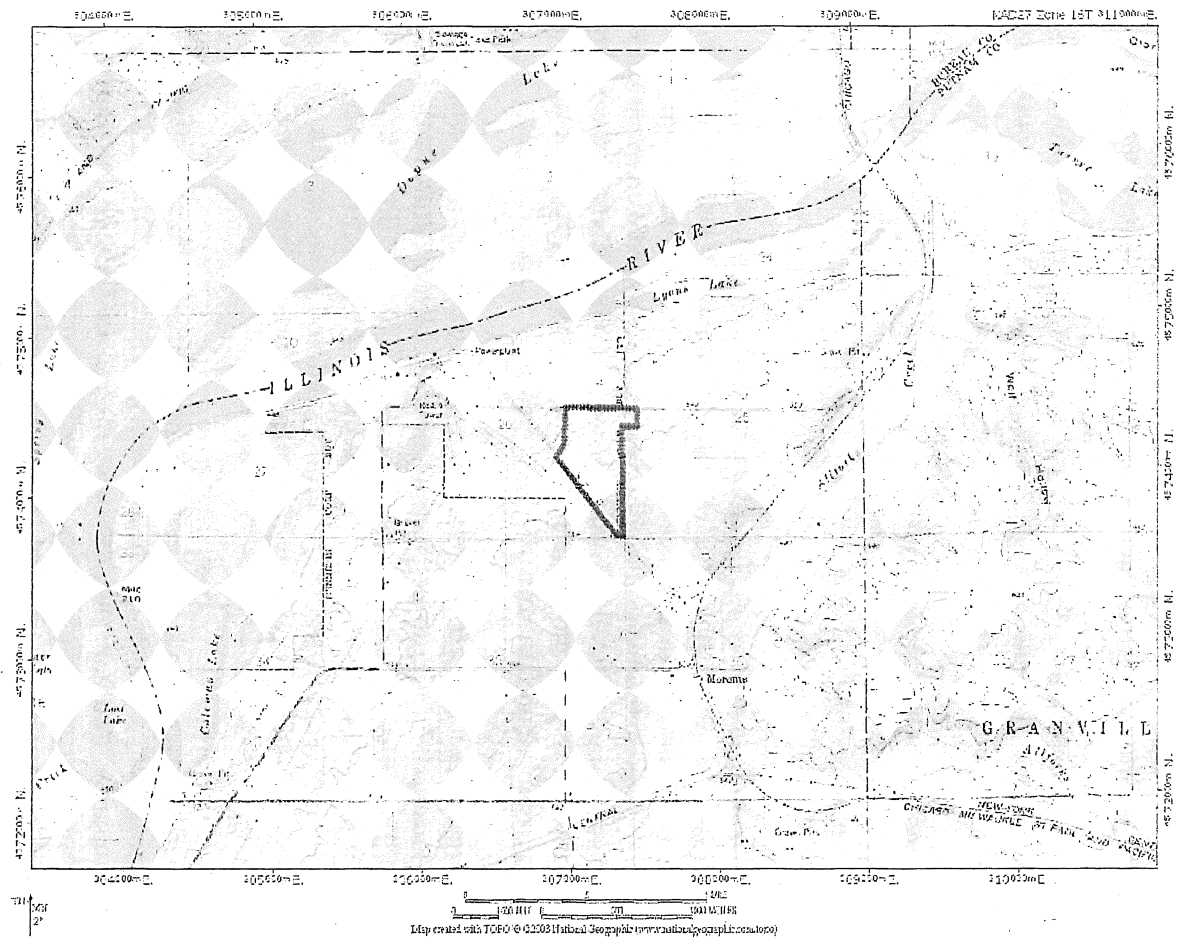
Figure 1   Map of WMH facility (outlined in blue) relative to surrounding geographic features

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2. Potential Habitats of Listed Species

2.1.   Indiana Bat

The endangered Indiana bat (*Myotis sodalis*) is an insectivorous migratory species. During the winter, colonies hibernate together in a small number of caves and abandoned mines, but during the summer, reproductive females disperse widely throughout the Midwestern and Eastern United States to bear and raise their young in maternity colonies. Since pregnancies are generally singletons (each female can bear only one pup per year), protection of maternity roosting habitat is vital to Indiana bat recovery.

Summer maternity roosting sites of the Indiana bat are generally under the exfoliating bark of dead or dying trees that receive direct sunlight for more than half the day. Such trees are most common in fragmented forest habitat or forest edges, such as those bordering agricultural or riparian areas.

Pregnant females must migrate to their preferred summer roosts just after their winter hibernation, when their fat stores are low. Additionally, pregnant and lactating females have high energy demands that require easy access to foraging areas from roosting areas. For these reasons, migration and roosting-foraging corridors are essential components of the reproductive female habitat. Tree-lined pathways appear to be preferred commuting corridors, and like other bat species, the Indiana bat seems to consistently prefer to travel along tree-lined paths rather than open areas.[1]

Indiana bats primarily eat flying insects, with a small amount of spiders. The orders of insect contributing most to their diet are Coleoptera (beetles), Diptera (true flies), Lepidoptera (butterflies, moths, and skippers), and Trichoptera (caddisflies). In the northern part of their range (which Putnam County, IL qualifies as), aquatic-based insects (flies and caddisflies) were dominant, probably because preferred foraging areas are more aquatic for northern bats. Indiana bats usually fly within airspace of 2 to 30 meters altitude.[2]

Reproductive females tend to return to their preferred maternity roosting areas every year. New, pioneer maternity colonies have never been documented.[3] Of the 28 recorded maternity colonies in Illinois, no cases occur in Putnam County. The nearest counties known to host maternity colonies are Ford and Henderson, over 100 kilometers away from Hennepin. However, Pecumsaugan Creek-Blackball Mines Nature Preserve in neighboring La Salle County hosts an Indiana bat hibernaculum with a growing

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[1] U.S. Fish and Wildlife Service (2007), Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision. U.S. Fish and Wildlife Service, Fort Snelling, MN. 258 pp. See p. 66
[2] Ibid., p. 50, 69, 49
[3] Ibid., p. 48

population[4] and there are other summer records of non-maternity colonies in La Salle County.[5] Maternity colonies range in distance from hibernacula, with very short (within-park) distances reported as well as a maximum migration of 575 kilometers.[6] Therefore it is possible that maternity colonies could establish and/or forage in appropriate habitat areas near the WMH facility, though it would be unprecedented.

Potential Indiana bat habitat in the vicinity of the WMH facility is mapped using land use/land cover data from the National Land Cover Database (NLCD).[7] The NLCD contains images of land cover using colors associated with defined land cover classes. In GIS software, the colors associated with the classes were redefined in order to specifically reflect the habitat preferences of the Indiana bat, as described in Table 1. The resulting map is shown in Figure 2.

From Figure 2, we can see that some green areas are spatially fragmented with connecting corridors, particularly connected to the east (where the nearest known hibernaculum is located) via pathways along the Illinois River. The green areas are often neighbored by yellow or blue areas, provided the sunlight needed for good roosting sites. Overall there is no reason to exclude the Indiana bat from consideration of potential impacts from the WMH facility.

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[4] Ibid., p. 26, Table 3
[5] Ibid, p. 30
[6] Ibid., p. 44
[7] NLCD 2001 data downloaded from http://seamless.usgs.gov/ on 11/19/07. U.S. Geological Survey EROS NLCD Land Cover Mapping Team (2006), National Land Cover Database Zone 49 Land Cover Layer, Edition 1.0. Sioux Falls, SD.

7

Potential Indiana Bat Habitat

Legend:
- Woods (commuting, roosting, foraging)
- Open water (commuting, foraging)
- Fields (neighboring, foraging)
- Developed or barren (not preferred)
- ✳ Exolon Location

4   0   4   8   12 Kilometers
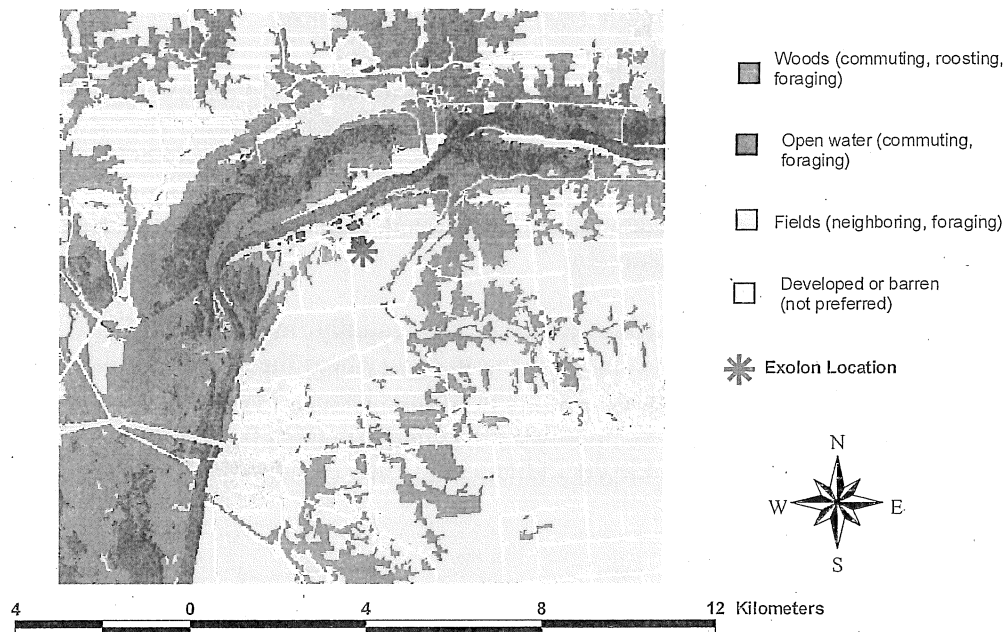
Figure 2   Potential Indiana bat habitat for summer maternity roosting, foraging, and commuting/migrating in the vicinity of the WMH facility derived from NLCD

Table 1   NLCD land cover definitions and coloration for Figure 2

Land Cover Class Code	Definition	Color in Habitat Map
41	deciduous forest	green
42	evergreen forest	green
43	mixed forest	green
90	forest wetland	green
11	open water	blue
95	grassy wetland	blue
96-127	various wetland types	blue
52	shrubs	yellow
71	grassland	yellow
81	hay/pasture	yellow
82	agriculture	yellow
21-24	developed	gray
31	barren	gray

2.2.   *Eastern Prairie Fringed Orchid*

The eastern prairie fringed orchid (*Platanthera leucophaea*) is an endangered perennial herb once widespread through tallgrass prairies.[8] It is has an upright leafy stem topped with a characteristic pattern of leaves and white fringed flowers, growing up to one meter in height. It occurs in a wide variety of habitats along a broad moisture gradient, from sandy-mesic prairies to emergent, shrubby wetlands. The orchid requires sunny, open conditions, commonly found in early or mid-successional phases of areas prone to local patch disturbances.[9]

Night-flying hawkmoths (Sphingidae family, particularly *Eumorpha pandorus*, *Eumorpha achemon*, and *Sphinx eremitis*) are considered the primary pollinators of the eastern prairie fringed orchid.[10] Since the orchid appears to rarely reproduce vegetatively, protection of pollinator populations is an important component of its recovery plan.[11]

Potential eastern prairie fringed orchid habitat is identified with both National Wetlands Inventory (NWI)[12] and National Land Cover Database data. NWI categories considered conducive to the Eastern Prairie Fringed Orchid are Palustrine Emergent (PEM) series wetlands, except those that are semipermanently to permanently flooded or forested, and Littoral Emergent (L2EM) series (lake coastlines or riverbanks). See
Figure 3. National Land Cover Database classes conducive to orchid habitat include 52 (shrubs/scrub), 71 (non-agricultural grassland), 90 (Woody wetlands), 92 (Palustrine shrub/scrub wetland), 95 (Emergent herbaceous wetland), and 96 (Persistent Palustrine emergent wetland). Developed, barren, and forested areas, as well as agricultural fields and intensively grazed or hay fields were not considered potential habitat. See Figure 4. For maps of potential habitat from NLCD land cover data for all the listed plant species in this report, potential habitat is always shown in green, open water in blue (for spatial reference), and areas not considered potential habitat in gray.

From the maps, we see that most potential orchid habitat near WMH is mesic rather than wet. Suitable habitats appear to exist in the area, although extant populations are not known to be present.[13]

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[8] U.S. Fish and Wildlife Service. 1999. Eastern Prairie Fringed Orchid (*Platanthera leucophaea*) Recovery Plan. Fort Snelling, Minnesota. 62 pp. p. 3
[9] Ibid., p. 6-7
[10] Ibid., p. 8
[11] Ibid., p. 14
[12] Seamless NWI wetlands data downloaded using the Wetlands Data Extraction Tool, accessed at http://wetlandsfws.er.usgs.gov/NWI/download.html on 11/19/07. U.S. Fish and Wildlife Service. 2007. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31.
[13] Recovery Plan, Figure 2, p. 4

9

Potential Eastern Prairie Fringed Orchid Habitat

Palustrine Emergent Wetlands, National Wetlands Inventory

Figure 3   National Wetlands Inventory identification of emergent wetland potential orchid habitat (green). Open water (blue) and the WMH location (red star) are shown for visual guidance.

Potential Eastern Prairie Fringed Orchid Habitat
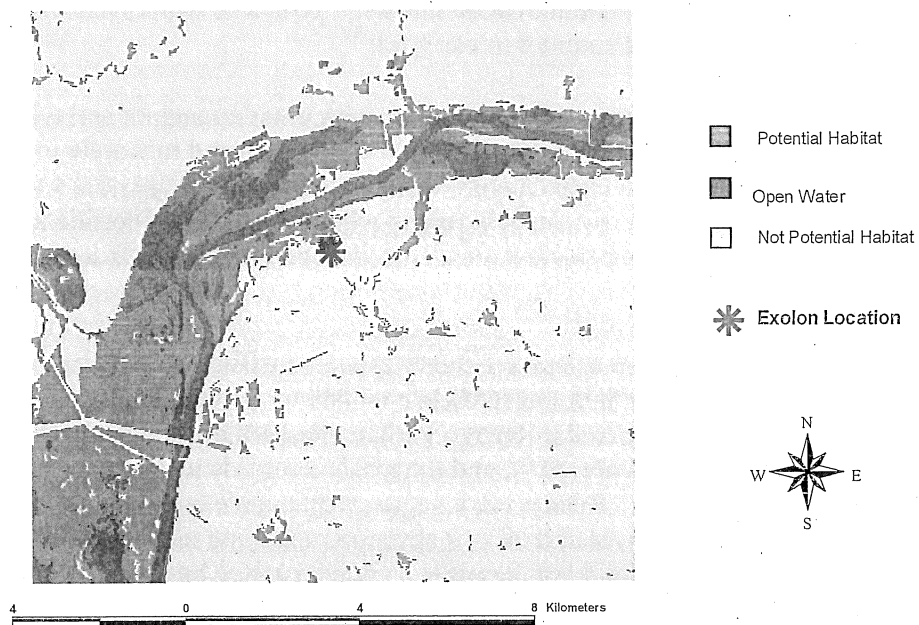
Figure 4   Potential orchid habitat derived from NLCD relative to WMH location

2.3. *Prairie Bush Clover*

Prairie bush clover (*Lespedeza leptostachya*) is a threatened tall, leafy perennial from the pea family. Its stem and leaves appear silvery-green because of being covered with fine hairs. It grows up to one meter tall and, upon maturity, produces white, yellowish-white, or pale pink flowers during late summer to early fall.[14]

Prairie bush clover is found in dry to mesic prairies with a wide range of soil types. Its habitat is vulnerable to being adopted for agricultural purposes and to woody invasion, since it appears to neither tolerate shade nor compete well with woody species for sunlight. The clover is thought to primarily reproduce by seed via self-fertilization, and although potentially out-crossing flowers are also produced there are no known pollinators.[15]

Prairie bush clover has never been found in either Putnam or Bureau counties, but populations exist north of Bureau in Lee and Ogle counties. It is extremely rare in Illinois in general.[16] According to the Recovery Plan, there are many apparently suitable habitats where the species does not grow, and the reasons for this were unknown at the time of the plan's publication.[17] Recent work suggests that some combination of hybridization with a related clover and lack of appropriate habitat management (which may include only light grazing and less burning or mowing) may be to blame.[18]

Potentially suitable habitats, as defined under the NLCD land cover classes, are shrubs (52) and grassland (71). Shrubs are considered potential habitat because open patches may exist within the land cover class. See Figure 5 for the map of potential prairie bush clover habitat. Although habitat is not terribly common in the area, there are relatively extensive patches just north and west of WMH along the river. Therefore prairie bush clover cannot be excluded from consideration of possible impacts from WMH.

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[14] U.S. Fish and Wildlife Service (1988). *Lespedeza leptostachya* Reovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 41pp. p. 1
[15] Ibid., p. 10-11
[16] Ibid., p. 2
[17] Ibid., p. 10
[18] Center for Plan Conservation, CPC National Collection Plant Profile: *Lespedeza leptostachya*. Accessed via http://www.centerforplantconservation.org/search.html on 11/27/07

12

Potential Prairie Bush Clover Habitat

Potential Habitat

Open water

Not potential habitat

Exolon location

3   0   3   6 Kilometers

N
W   E
S
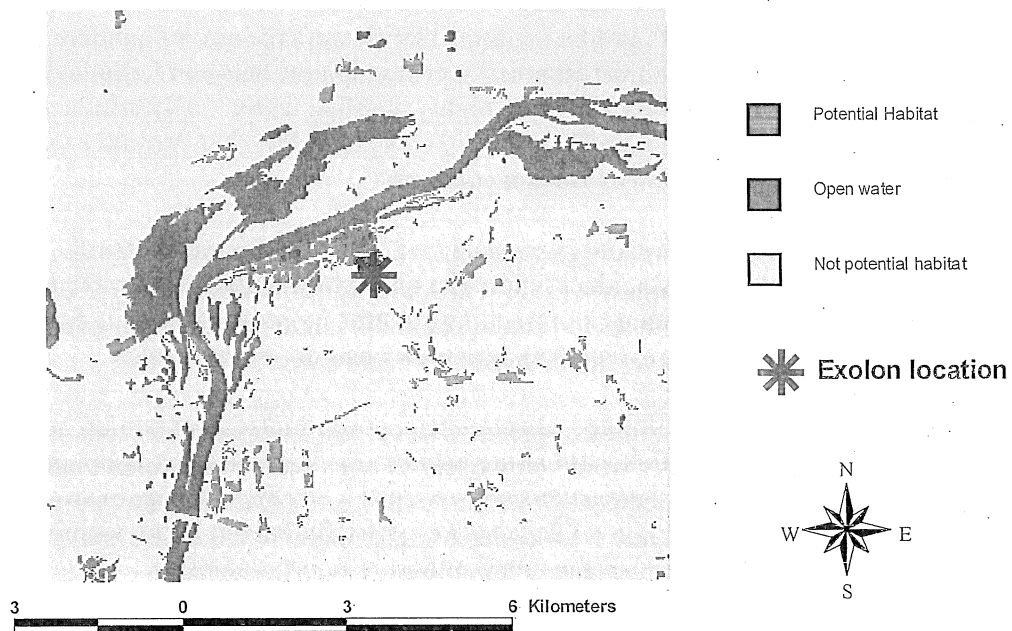
Figure 5   Potential prairie bush clover habitat in the WMH vicinity as identified by NLCD
land cover.

2.4.   Decurrent False Aster

Decurrent false aster (Boltonia decurrens) is a threatened wet prairie perennial which can grow more than two meters tall, producing aster-like flowers the size of quarters.[19] It has historically been associated with the Illinois River floodplains between LaSalle, IL and St. Louis, MO, making the WMH vicinity a highly possible habitat. Historic records indicate past populations in Putnam County very close to WMH, but currently there are no known populations in Putnam or Bureau counties.[20]

The decurrent false aster is commonly associated with floodplains and wetlands, preferring saturated soils and abundant light. The major limiting factors for the decurrent false aster are believed to be changes in flooding patterns inducing heavy silt deposits, as well as wetland draining for conversion to agriculture and use of herbicides.[21]

The NLCD land cover classes defined as potential decurrent false aster habitat are woody wetlands (90) (although the asters would only occur in open patches or edges), palustrine shrub wetlands (92), emergent herbaceous wetlands (95), and persistent palustrine emergent wetlands (96). See Figure 6 for a map of potential habitat in the vicinity of WMH. Most habitat occurs, as expected, in the Illinois River floodplain.

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[19] U.S. Fish and Wildlife Service (1990). Decurrent False Aster Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 26 pp. p. 1
[20] Ibid., Figure 1, p. 3-4
[21] Ibid., p. 7

Potential Decurrent False Aster Habitat
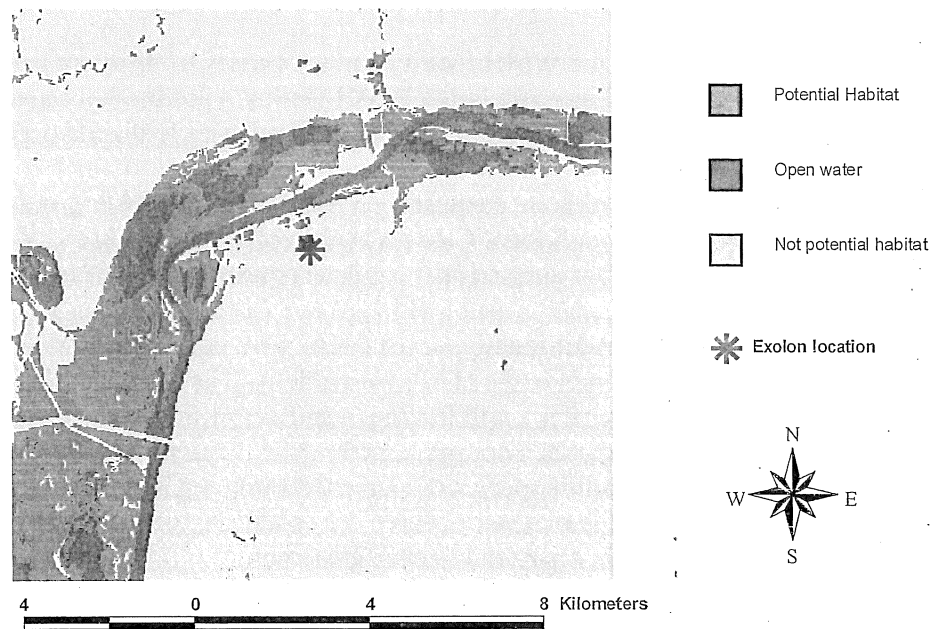
Figure 6   Potential decurrent false aster habitat in the WMH vicinity, as identified by NLCD
land cover

3. Fate and Transport of WMH Emissions

3.1.   Chemicals of Potential Concern

Like most industrial facilities, the WMH facility emits a variety of different pollutants to the atmosphere. The proposed increase in the WMH facility's production capacity will emit more of the same pollutants that the facility already releases to the atmosphere.

WMH emits various Criteria Pollutants, Hazardous Air Pollutants (HAPs), and other chemicals that fall outside the traditional Clean Air Act pollutant categories. Of all pollutants, sulfur dioxide (SO_2) is emitted in the greatest quantity. WMH also emits nitrogen oxides (NO_x) and particulate matter (PM_{10}) (two Criteria Pollutants associated with potential ecotoxicity).[22] Additionally, several HAPs are considered. Volatile organic compound emissions include the HAPs formaldehyde and hexane. Carbonyl sulfide (COS), carbon disulfide (CS_2), and hydrogen sulfide (H_2S)[23] are emitted as residual sulfur-containing compounds not processed by the facility's Sulferox unit (designed to convert reduced sulfur species to elemental form). All of these pollutants are released from the facility's stack (point source). In addition, there are some fugitive particulate matter emissions from material handling sources.

Particulate matter from the incidental material (coke and silicon carbide product) emissions also contains some metals. Three of these metals – aluminum, nickel, and vanadium – are evaluated due to their status as HAPs and/or chemicals of potential ecotoxicity.

Table 2 summarizes the incremental emissions of pollutants associated with the proposed facility expansion.

3.2.   Conceptual Exposure Model

Figure 7 presents a conceptual exposure model summarizing emissions from the WMH facility expansion and the fate and transport of those emissions in the environment. As discussed above, SO2, NOx, PM, HAPs, and residual sulfur-containing compounds are emitted from the facility's stack. Additional particulate matter emissions result from

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[22] WMH also emits carbon monoxide (CO) and volatile organic compounds (VOCs). CO is not considered a potential ecotoxin, and VOCs cannot be evaluated as a class (though some individual VOCs are considered).

[23] H_2S is not a designated Hazardous Air Pollutant.

fugitive sources including material processing, equipment traffic in the yard, raw material transfer to the new furnace group, and wind erosion from storage piles.

SO_2 can dissolve in water droplets in the atmosphere and hydrolyze to create acid fog or acid mist which, if sufficiently acidic, could adversely affect vegetation growing in the vicinity of the WMH facility. While nitrogen oxides can also react with water droplets to create nitric acid, SO_2 is expected to be the greatest contributor to acid fog. SO_2 is emitted by the WMH facility at approximately ten times the rate at which NO_x is emitted. Furthermore, the atmospheric chemistry of SO_2 is straightforward and easily modeled while NO_x can react to form both nitric acid and ammonium nitrate. Because SO_2 is emitted at a much greater concentration than NO_x, the acid fog analysis focuses only on SO_2.

Emissions from the WMH facility will increase the ambient concentrations of the gases SO_2, NO_x, COS, CS_2, H_2S, formaldehyde, and hexane in the vicinity of the plant. Particulate matter emissions can deposit to plant surfaces, potentially interfering with photosynthesis. The endangered species evaluation therefore evaluates both potential phytotoxicity of increased ambient concentrations of contaminants and potential adverse effects of deposition of particulate matter to plant surfaces.

Particulate matter can also deposit to soil, surface water, and sediment. Over time, the accumulation of particulate matter deposited from the atmosphere can increase the concentrations of its constituents in soil, surface water, and sediment. The endangered species evaluation therefore evaluates the potential long-term effects of the potential accumulation of aluminum, nickel, and vanadium in soil, surface water, and sediment over 100 years of facility operation.

3.3.   *Modeling of Potential Impacts*

The AERMOD model was used to model dispersion and deposition of pollutant emissions from the WMH facility. RK & Associates provided the modeling and materials analysis support, and submitted a description of the model setup for the acid fog analysis and particulate matter analysis which is contained in Appendix B.

As expected, for all time scales and species modeled, maximum impact receptors occurred within a 3 km radius of the facility. See Figure 8 for a map of receptor sites used for gaseous species and PM modeling, as well as locations of maximum impact receptors.

Table 2 Emission rates of chemicals of potential concern

Chemical of potential concern	Emission rate (tpy)	Emission rate (g/s)
Sulfur dioxide (SO_2)	5.07E+02	1.46E+01
Nitrogen oxides (NO_x)	3.96E+01	1.14E+00
Total Particulate Matter	2.01E+01	5.79E-01
Hydrogen sulfide (H_2S)	1.49E+00	4.29E-02
Carbonyl sulfide (COS)	1.87E+00	5.38E-02
Carbon disulfide (CS_2)	1.12E+00	3.22E-02
Formaldehyde	1.07E-02	3.08E-04
Hexane	2.58E-01	7.41E-03
Aluminum	7.66E-04	2.20E-05
Nickel	2.01E-04	5.79E-06
Vanadium	4.73E-04	1.36E-05

Notes:

Emission rates for SO2, NOx, H2S, COS, and CS2 are from the PSD construction permit application for the C5 furnace group (RK & Associates, 2007).

Emission rates for formaldehyde and hexane were provided by RK & Associates (via email from Suresh Relwani and Darina Demirev to Stephen Zemba and Sara Hendrix of Cambridge Environmental Inc. December 20, 2007).

Emission rates for metals are based on emission rates of coke and silicon carbide as modeled by RK & Associates combined with average mass fractions of aluminum, nickel, and vanadium in both coke and silicon carbide as measured by a materials analysis (provided to Cambridge Environmental by RK & Associates via email). Total emission rates for coke and silicon carbide were 1.17 and 0.172 tpy, respectively. Mass fractions of aluminum, nickel, and vanadium in coke are 5.80E-04, 1.72E-04, and 3.25E-04, respectively. Mass fractions in silicon carbide are 5.10E-04 (aluminum), 0 (nickel), and 5.40E-04 (vanadium).

Total sulfur dioxide emissions (including both present existing emissions and emissions from proposed expansion) were utilized in the acid fog analysis, in order to obtain a conservative estimate of total pH reduction since background pH data sources were not considered fully representative and the pH calculation is non-linear. A value of 110.36 g/s was utilized for total (existing plus proposed) sulfur dioxide emissions. The rate was provided via email from Darina Demirev of RK & Associates to Sara Hendrix of Cambridge Environmental Inc. on December 7, 2008.

SO₂ only

Gases: SO₂
NO_x
COS, CS₂, H₂S, Formaldehyde, Hexane

Acid Fog

Potential effects
on vegetation

PM (Al, Ni, V)

Deposition
to plants

Deposition
to soil,
surface water,
and sediment

S
T
A
C
K

Fugitive sources & Material processing

WMH Facility
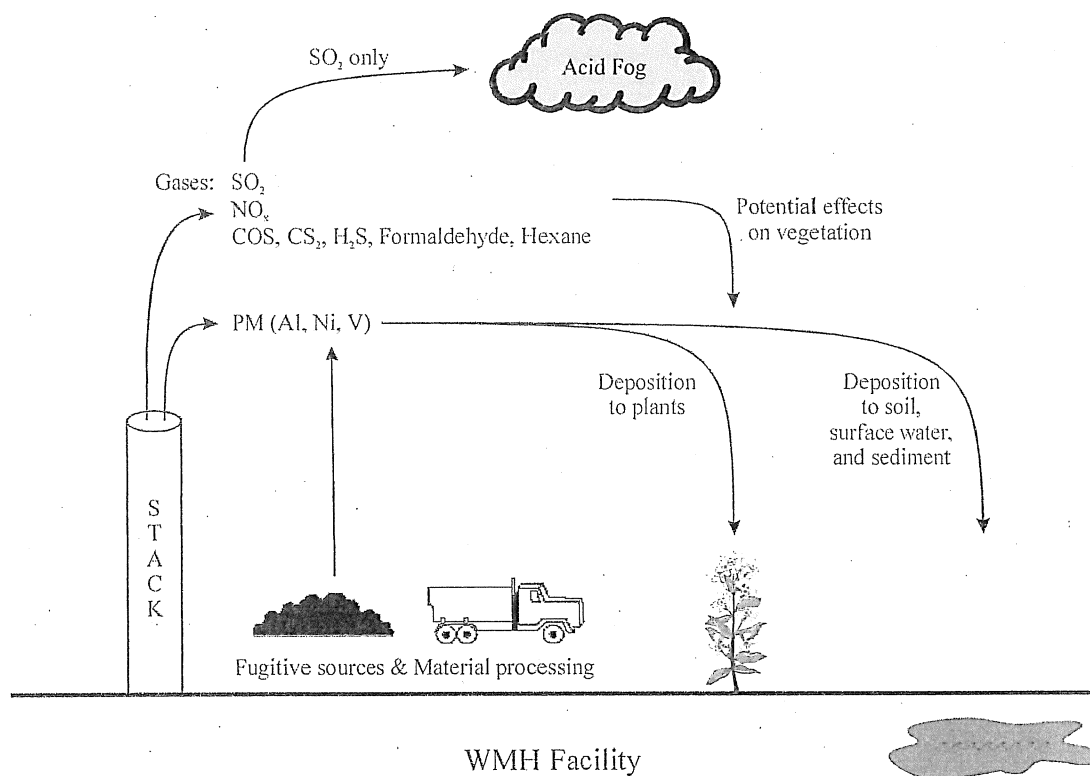
Figure 7   Conceptual exposure model showing the fate and transport of WMH emissions
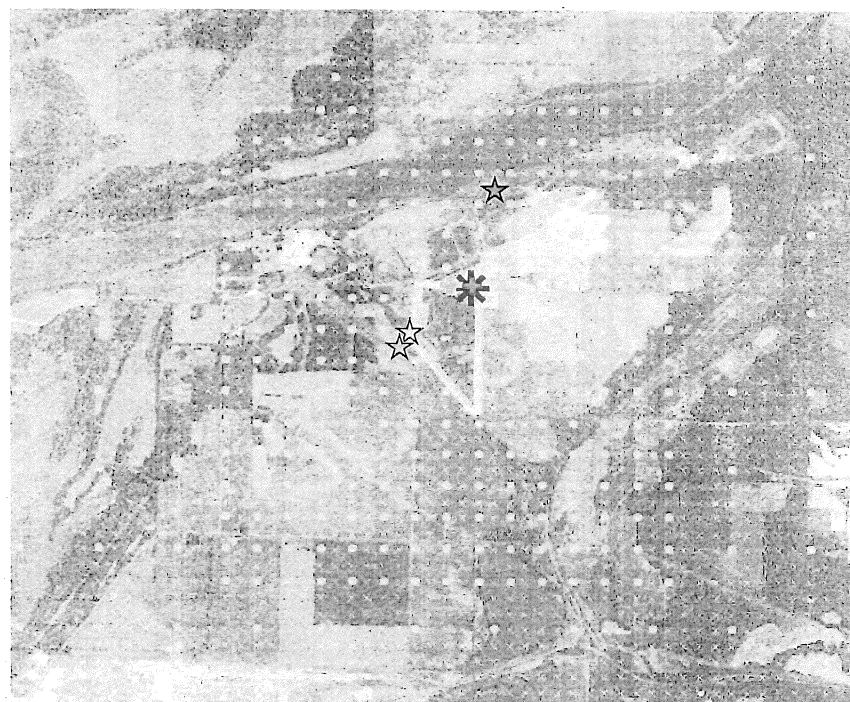
Maximum Impact Receptors

☆ Gaseous 24-hr Max Conc

☆ Gaseous 3-hr Max Conc

☆ Gaseous Annual Max Conc

✳ Oxidizer Stack

PM Annual Max Conc
PM Annual Max Dry Dep
✚ PM Annual Max Wet Dep
Gaseous Receptors
PM Receptors
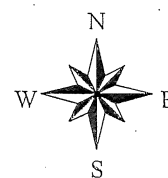
1   0   1   2 Kilometers

Figure 8   Modeled receptors within 3 km of WMH facility

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4. Short-term Impacts Assessment

4.1. Acute Effects

Potential acute effects due to the proposed WMH expansion include both direct phytotoxicity from elevated ground-level concentrations of atmospheric pollutants, and deposition of particulate matter to vegetation leaf surfaces which has the potential to interfere with photosynthesis. Acute exposure is evaluated over short-term periods of hours to weeks, as opposed to chronic effects (evaluated in Section 5) that are considered over long-term (annual and multi-year) periods

4.1.1. Direct Phytotoxicity

Phytotoxicity (direct damage to plants, such as necrosis of leaves and stems or stunted growth) historically has been the basis for definitions of short-term exposure benchmarks for vegetation to atmospheric pollutants. In recent years, however, the World Health Organization has developed ecological guidelines ("critical levels") meant to protect vegetation and ecosystems from more subtle effects.[24] For example, nitrogen compounds in air may, at certain levels, actually promote growth, but with a higher shoot-to-root ratios that can put the plants at risk for damage from frost, drought, or pests. These criteria levels are generally lower than the screening concentration benchmarks based on direct damage, sometimes dramatically lower.[25] For completeness, when short-term and annual maximum modeled exposures in this report are compared to benchmarks, all available ecological screening concentrations and WHO criteria levels are presented.

Comparisons are shown in Table 3, which provides estimates of the worst-case incremental concentrations expected from increased WMH facility emissions, representative background levels, and effects-based guideline concentrations. All acute increments result in total concentrations well below the most protective benchmarks, and tend to represent small fractions of background concentrations as well. Overall the modeling predicts no danger of direct phytotoxicity or of ecological harm due to acute impacts from proposed WMH expansion, and the incremental concentrations of pollutants due to increased emissions from the WMH facility are not expected to substantially change existing background air quality.

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[24] World Health Organization (2000), Air Quality Guidelines for Europe, Second Edition. WHO Regional Publications, European Series, No. 91.
[25] The WHO guidelines are also considerably lower than air quality standards (such as the national standards promulgated by the U.S Environmental Protection Agency).

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4.1.2. *Particulate Deposition to Leaf Surfaces*

As an additional consideration, sufficiently high deposition rates of total particulate matter can interfere with normal plant respiration. Reduced levels of photosynthesis have been observed at elevated particulate matter loadings. A steady-state level of dust on plant surfaces can be estimated with the following model (as simplified from EPA): [26]

$$S_{plant} = \frac{D_{dry} + f_{wet} D_{wet}}{k_p} \qquad \text{Equation 1}$$

where the terms are:

S_{plant}	Steady-state loading on the plant surface (g/m^2);
D_{dry}	Rate of dry deposition (g/m^2-yr);
D_{wet}	Rate of wet deposition (g/m^2-yr);
f_{wet}	Fraction of wet deposition that remains on the plant surface; and
k_p	Plant surface loss coefficient (1/yr).

AERMOD predicts worst-case dry and wet particle deposition rates of 2.19 g/m^2-yr (D_{dry}) and 0.367 g/m^2-yr (D_{wet}), respectively. EPA recommends values of 0.6 for f_{wet} and 18 yr^{-1} for k_p, respectively.[26] Using the maximum modeled dry and wet deposition rates described above, Equation 1 predicts a particle loading of 0.13 g/m^2. This worst-case level, predicted using maximum model predictions, is below the range of 1-10 g/m^2 at which reduced levels of photosynthesis have been observed in some plant species.[27] Therefore no harm to endangered plants from particulate matter deposition is predicted.

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[26] U.S. EPA (2005). *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. EPA 530-R-05-006.
[27] Glenn, D., and Puterka, G. (2005). Particle Films: A New Technology for Agriculture. *Horticultural Reviews* **31**:1–44.

Table 3   Acute modeled increments and comparison to background and benchmarks.

Chemical of Concern	Averaging time	Projected increment due to proposed WMH expansion ($\mu g/m^3$)	Background concentration ($\mu g/m^3$)	Ratio: Projected increase to background	Benchmark protective of sensitive vegetation ($\mu g/m^3$)[D]
Sulfur dioxide (SO₂)	3 hours	26	419[A]	0.06	786
	24 hours	14	118[A]	0.12	734[E]
Nitrogen oxides (NOₓ)	3 hours	2	63[B]	0.03	3760[F]
	24 hours	1	34[B]	0.03	564[G]; 75[H]
Hydrogen sulfide (H₂S)	3 hours	0.1	0.46[C]	0.22	28,000[F]; 13,941[I]

Notes:

A   Data from Illinois EPA (2006), Illinois Annual Air Quality Report 2005, 1st highest samples in 2005 from Oglesby.

B   Derived from hourly NOₓ data downloaded for the 2006 calendar year from the U.S. EPA's Air Quality System database (http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm). Braidwood, IL, in Will County, was selected as the closest available monitoring station to the WMH facility. The 24-hr maximum daily value of 34 ug/m3 (0.018 ppm) was measured on June 2, 2006. The highest 3-hr NOx concentration (running average) of 63 ug/m3 (0.034 ppm) was measured on April 26, 2006.

C   Upper bound estimated hydrogen sulfide ambient air concentration, from: Sciences International, Inc (1999), Toxicological profile for hydrogen sulfide, prepared for the U.S. Department of Health and Human Services.

D   Source, unless otherwise noted: U.S. EPA (1980), A screening procedure for the impacts of air pollution sources on plants, soils, and animals. EPA 45C/2-81-078. Table 3.1, screening concentration values for most sensitive vegetation.

E   Concentration to cause traces of leaf destruction over 24 hours calculated from: $(C - 0.24)t = 0.94$, t in hours, C in ppm (result: 0.28 ppm, 734 $\mu g/m^3$). Equation is from World Health Organization (1961), Air Pollution, Effects of air pollution on plants, MD Thomas. WHO Monograph Series No. 46, p. 239.

F   Screening concentration is for 4 hour averaging time as more conservative proxy.

G   Screening concentration is for 1 month averaging time as more conservative proxy.

H   Critical level from WHO Air quality guidelines for Europe, Second edition, p. 232.

I   Lowest available NOAEL for animals (Fischer-344 Rat) of 10 ppm, from p. 17 of the toxicological profile for hydrogen sulfide (see above), reference 19.

4.2.   *Acid Fog Analysis*

Acid fog is a less well-studied phenomenon than its cousin, acid rain. Whereas acid rain is a regional problem caused by long-range transport and synoptic weather patterns, acid fog may in some cases provide a mechanism for near-source acid deposition of acid sources. Acid fog or mist, if sufficiently acidic, could damage vegetation in the same manner as acid rain and reduce habitat quality for endangered plant species; hence its consideration in this analysis. In the case of WMH, sulfur dioxide is the only significant possible acid source (see Section 3.2), and hence serves as the focus of analysis.

Formation of atmospheric sulfate ($SO_4^=$) from sulfur dioxide (SO_2) can be much more rapid within the aqueous phase than the gas phase under appropriate conditions. Field studies have found the SO_2-to- $SO_4^=$ conversion rate in clouds or fogs to be ten times or more the rate in clear atmospheres.[28] (Dry acid particle deposition will not be considered in the acid fog analysis for this reason.) The absorption of sulfur dioxide into droplets is more efficient with a high density of small drop sizes which increase the surface-to-volume ratio and effective surface area for absorption. Such conditions are common in clouds in general (the "wet scavenging" modeled by long-range transport models) and in fog or mist in particular. Although the processes and impacts of acid fog are not well understood in terms of near-field deposition, a simple model is constructed to estimate a conservative yet plausible minimum fog pH which could potentially result from WMH emissions in the near field (3 km radius). Sulfur dioxide gas absorption and oxidation to aqueous sulfate within fog has been the subject of a few empirical studies in the literature,[29,30,31] and relevant results from these will be utilized.

The acid fog evaluation begins with an assessment of the history of fog in the area using a detailed 5-year dataset of meteorological observations. Then, utilizing AERMOD estimates driven by the same meteorology over the same time period, maximum-impact SO_2 concentrations during fog and mist events in growing season months are examined and the conversion of $SO_2(g)$ to $SO_4^=(aq)$ modeled for each fog or mist event. A representative worst-case background pH is used as a baseline to estimate the pH resulting from the WMH-related sulfate, and that value is compared to the benchmark for plant injury effects.

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[28] Bamber, DJ, PA Clark, GM Glover, PGW Healey, AS Kallend, ARW Marsh, AF Tuck, amd G Vaughan (1984). Air sampling flights round the British Isles at low altitudes: SO_2 oxidation and removal rates. Atmospheric Environment 18(9), 1777-1790. See also Eatough et al, cited below.
[29] Eatough, DJ, RJ Arthur, NL Eatough, MW Hill, NF Mangelson, BE Richter, LD Hansen, and JA Cooper (1984). Rapid conversion of $SO_2(g)$ to sulfate in a fog bank. Environ. Sci. Techno. 18, 855-859.
[30] Klemm, O, RW Talbot, and KI Klemm (1992). Sulfur dioxide in coastal New England fog. Atmospheric Environment 26A(11), 2063-2075.
[31] Pandis, SN and JH Seinfeld (1992). Heterogeneous sulfate production in an urban fog. Atmospheric Environment 26A(14), 2509-2522.

24

4.2.1.   Fog History

Highly detailed weather observations including fog and fog types are typically only available from larger airports. The nearest, most representative, and complete weather station to WMH is the Peoria Airport, approximately 45 miles to the south and also near the Illinois River. Since the Peoria weather data were also used to drive the AERMET/AERMOD meteorology, comparing the Peoria fog history to the AERMOD modeled SO_2 concentrations provides a reasonable estimate of how weather conditions are likely to correlate with high SO_2, and thereby high sulfate and low pH fog or mist. Also, since Peoria is relatively nearby and has similar agricultural river plain surroundings, we expect the climatology to be quite similar to that found at WMH. Climatology refers to average overall weather patterns, the expected climate depending on time of year. The specific days when certain weather is observed in Peoria may not correspond exactly to the weather at WMH, but it will be similar enough that the statistics of the multi-year record will be a good representation of WMH area conditions.

The two main aspects of climatology of interest from an endangered species perspective are the time of year and the time of day. The time of year is important because acid fog occurring during the winter is not of concern, since plants are not growing and (in particular the endangered plants in this analysis) are not emergent above ground. For this reason the acid fog analysis is restricted to the growing season only. The time of day is important because atmospheric stability, winds, and other atmospheric dynamics relating to plume dispersion (and thus SO_2 concentrations) are highly dependent on diurnal dynamics. These effects are accounted for by driving AERMOD with the same meteorology used for the fog history assessment.

Hourly surface from January 1, 2002 through December 31, 2006 data for the Peoria airport was accessed via the National Climatic Data Center (NCDC).[32] The dataset includes four fields where qualitative descriptions of weather conditions can be recorded using a code system. Codes 11-12 (shallow fog), 28 (fog or ice fog), and 40-49 (fog) were all considered fog, so that if any of the four weather descriptor fields contained at least one of these numbers, that time period was recorded as "fog". Code 10 (mist) was also recorded as "mist," but if fog was also reported, then the time period was labeled "fog." It is important to differentiate between fog (usually defined as limiting visibility to less than 1 km) and mist (visibility less than 2 km). Whereas fog is assumed to have a liquid water content of 0.1 g/m^3, mist, being much less thick, is assumed to have a liquid water content of 0.01 g/m^3.[33] Acid mist is potentially much more acidic than acid fog given the same SO_2 concentration, since there is less water to dilute the sulfate.

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[32] See http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI~StnSrch~StnID~20005809
[33] In Klemm et al (1992), liquid water contents were tabulated for six fog events. Maximum liquid water content was 0.79 g/m^3 and minimum was 0.009 g/m^3; all events were considered "fog". This provides a reality check that our assumed liquid water contents are basically realistic yet conservative.

The climatology of fog and mist from the 5-year Peoria observation record are summarized in Figure 9 - Figure 11. Overall, Peoria experiences fog around 9% of the time and mist 12% of the time. However, more fog and mist occurs in the winter than the growing season, likely in the form of advection fog due to warm moist Gulf of Mexico air passing over the snow.[34] During the growing season, the frequency of fog and mist is lower, about 6% and 10% of the time respectively. The majority of fog and mist events last only one hour and the average duration is a few hours, but some can last close to a full day.

4.2.2. *SO₂ Impacts during Fog*

From the SO_2 AERMOD modeling, a maximum impact receptor for 3-hour concentrations was selected as the receptor of interest for the acid fog evaluation. The highest impact points were along the WMH perimeter, but another comparatively high impact receptor was located some 540 meters away in a patch of potential endangered species habitat. See Figure 12 for a map of the receptor location on top of aerial orthoimagery from 2004. For this receptor, an AERMOD run produced an hourly time series of SO_2 concentrations for the 2002-2006 period resulting from total WMH facility emissions, not just incremental impacts from the proposed expansion. Inclusion of the total emissions was deemed necessary in order to account for non-additive effects in the pH calculation and a regional scale background pH not necessarily representative of actual present conditions in the WMH vicinity.[35] The time series was filtered by co-occurrence with fog or mist during the growing season, and the resulting distributions of SO_2 concentrations during fog/mist events are depicted in Figure 13.

The graphs in Figure 13 are restricted to show the details of how the highest concentrations of SO_2 are distributed. The presentation via 75-100th percentiles shows that the vast majority (>85%) of the hourly SO_2 data are of negligible magnitude (<5 $\mu g/m^3$), but occasional modeled events predict higher, though still well below the most protective screening-level[36] concentrations. To see how the SO_2 could affect fog or mist pH, an acid fog model is required.

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[34] Ritter, ME (2006). The Physical Environment: an Introduction to Physical Geography. Atmospheric Mouisture. Accessed 12/3/07.
http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/title_page.html
[35] See Section 4.2.4 (Background Determination) for an explanation of why the total emissions were necessary to consider.
[36] 1-hour SO_2 screening concentration for sensitive vegetation is cited as 917 $\mu g/m^3$ by U.S. EPA (1980), A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals. EPA 450/2-81-078. Maximum hourly SO_2 concentrations modeled in this analysis are around 100 $\mu g/m^3$.

4.2.3.   *The Acid Fog Model*

Most of the sulfur in WMH emissions is expected to be in the form of SO_2. Once emitted, SO_2 is further oxidized to $SO_4^=$ in the atmosphere, a form more readily removed by deposition processes. However, because chemical reactions are required, the SO_2 to $SO_4^=$ conversion requires time to occur, and the rates of conversion are slow enough to typically allow sulfur emissions to travel hundreds to thousands of miles before removal/deposition occur (leading to the phenomenon of acid rain). Conversion rates for SO_2 to $SO_4^=$ found in field studies reflect that, at a given distance from the emission source, only a fraction of SO_2 gas emissions have actually been converted to aqueous sulfate. However, during fog conditions, SO_2 to $SO_4^=$ conversion rates can be accelerated. To simplify the heterogeneous chemistry, we assume that all SO_2 gas is absorbed into the liquid water of the mist or fog.[37] This step takes us from a dry SO_2 concentration in air to an aqueous molarity of SO_2 in water. Then the SO_2 converts to $SO_4^=$ according to a linear conversion rate, with a first-order approximation given by:

$$[SO_4^=] = (1 - e^{-kt}) \cdot [SO_2] = (1 - e^{-k_{con}\frac{d}{u}}) \cdot [SO_2] \qquad \textbf{Equation 2}$$

where the terms are:

$[SO_4^=]$	Concentration of $SO_4^=$ in aqueous solution, moles/L;
k_{con}	Conversion rate of the SO_2 gas to aqueous, ionized $SO_4^=$ (1/s);
t	Pollutant residence time in the atmosphere (s);
d	Distance of travel from the emission source (m); and
u	Wind speed (m/s).

The limits of Equation 2 reflect no initial conversion at the point of emission ($[SO_4^=]$=0 at d=0) and complete conversion at distances far from the source ($[SO_4^=]$=$[SO_2]$ at d=∞). Since our maximum impact ecological receptor is just 540 meters away from the stack, travel time to the receptor is always under one hour (assuming wind speed greater than 0.15 m/s, which is well below the detection limit of the Peoria anemometer in any case). Therefore, since we have SO_2 concentrations as well as wind speeds by hour for all modeled hours in the relevant record (2002-2006, fog or mist events during the growing season), it is straightforward to transfer all relevant hourly SO_2 concentrations to an equivalent hourly $SO_4^=$ concentration. The value of parameter k_{con} in this part of the model is discussed in Section 4.2.5. This step of the model assumes that the parcel from the stack travels directly to the receptor in a straight line, *i.e.*, the wind vector points directly at the receptor at all times.

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[37] Alternatively, the model could assume that the rate of SO_2 absorption into droplets was the limiting factor, and all SO_2 which absorbs is instantly converted to $SO_4^=$. Both assumptions have the same effect in terms of equations used in the model. In reality, both SO_2 absorption and aqueous oxidation limit the overall conversion. The interaction between the two limitations under various circumstances is still an unresolved problem in the acid rain/fog literature, which is why overall conversion rates are measured.

27

To compute fog or mist pH_{post} from the $[SO_4^=]$ due to WMH, a background or preexisting pH_{back} must be known. The new pH is computed via:

$$pH_{post} = -\log_{10}\left\{2\cdot[SO_4^=]+10^{-pH_{pre}}\right\}$$ Equation 3

which uses the simple pH definition, $pH = -\log_{10}([H^+])$ and the -2 charge of the sulfate ion.

To summarize, the steps of the acid fog model are:
1. All dry SO_2 is transferred to the aqueous phase inside the fog or mist liquid water;
2. SO_2 is converted to $SO_4^=$ in a simplified linear approximation, using an empirically observed conversion rate, observed hourly wind speeds, and known distance to receptor; and
3. From a background pH and the molarity of $SO_4^=$ a new pH reflecting the contribution from WMH is calculated.

In this manner, a statistical sample of pH during growing season fog or mist events for the 2002-2006 time period is generated. The pH is underestimated (*i.e.*, predicted at lower, or more acidic, values than likely to occur) by a combination of conservative model assumptions (parcels transport directly to receptor; all SO_2 is available in the aqueous phase) and a conservative treatment of background pH.

4.2.4.   Background pH Determination

Several wet deposition monitoring sites run by the National Atmospheric Deposition Program[38] (NADP) are available within Illinois. These stations monitor precipitation, aqueous concentrations of major anions and cations including Ca^{2+}, Mg^{2+}, K^+, Na^+, NH_4^+ NO_3^-, Cl^-, $SO_4^=$, and precipitation pH. The precipitation pH can be taken as a background pH level for clouds in the region. Most NADP sites are not located in the direct vicinity of emission sources such as urban areas. The three closest sites to WMH are Monmouth, Shabbona, and Bondville (see Figure 14). The finest timescale with pH data is the weekly data. The lowest weekly lab-measured pH for any of the three sites between the years 2002-2006 was 3.6, at Bondville; this site had an average weekly pH of 4.9 over the same period. The value used in acid fog model pH calculations is 3.6, a value purposely biased to provide an underestimate (low pH) of the typical acidic baseline to which WMH impacts might add.

Figure 15 and Figure 16 show data from the 5-year record of weekly pH in precipitation observations at Bondville. Only two weeks in five years had a pH less than 4. Figure 16 shows that the two low pH weeks occurred with near-zero (1 and 0.5 mm) weekly rainfall. High pH weeks also tended to occur with low rainfall. From the figure, it is clear that although low rainfall is no guarantee of extreme pH values, extreme pH values

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[38] The NADP has more than 250 cooperators and is located at the Illinois State Water Survey. Wet deposition is taken from the National Trends Network (NTN). http://nadp.sws.uiuc.edu/

that do occur seem to require very low precipitation (such as might occur from fog/mist). This underscores the importance of this analysis: in low precipitation events like fog, the ionic species responsible for overall pH have less liquid water for dilution, so that extreme pH values may be attained under certain circumstances.

This background pH possibly does not represent the lowest possible pH on an hourly timescale (the timescale of the acid fog model). Moreover, it is necessarily removed spatially from major emission sources and so may underrepresent the presently existing fog water acidity in the vicinity of WMH. For this reason, rather than considering only the SO_2 emissions resulting from WMH's proposed expansion, total (existing plus expansion) facility emissions from are considered to contribute to the worst-case fog pH. The fog pH distributions calculated by the model are very likely to represent worst-case conditions.

4.2.5.   *Sulfur Dioxide to Sulfate Conversion*

The SO_2 [S(IV)] to $SO_4^=$ [S(VI)] oxidation process inside fog banks is complicated by many factors, primarily the availability of various oxidants.[39] Hydrogen peroxide (H_2O_2) is the dominant oxidant when it is available, since oxidation of S(IV) by H_2O_2 is insensitive to pH and occurs very rapidly – so rapidly, in fact, that in field situations H_2O_2 is generally used up within minutes to hours.[40] The next most dominant oxidant is ozone (O_3), although O_3 oxidation of S(IV) is highly pH dependent and is not significant if pH is less than 5.5, making O_3 oxidation self-limiting. However, if neutralizing species such as NH_3 are present, the pH can remain high enough for O_3 oxidation to continue and allow for nearly complete S(IV) conversion.[41]

In light of the supreme importance of oxidant or oxidation-catalyst species presence for S(IV) → S(VI) conversion, it is relevant to discuss the nature and composition of the WMH emissions. As opposed to a conventional coal or oil-fired power plant plume, silicon carbide production involves byproducts of reduced (S(-II)) gaseous sulfur compounds which the Sulferox system oxidizes to SO_2 (S(IV)) before emission. A barely detectable amount of reduced sulfur is emitted as well.[42] Considering that the process is specifically designed to thermally oxidize the reduced sulfur species as much as possible before release, the SO_2 released to the atmosphere is not expected to be co-emitted with any significant oxidants. Ozone, peroxides, and ammonia are not among the emission

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[39] E.g., see Pandis & Seinfeld, 1992

[40] Fung, CS, PK Misra, R Bloxam, and S Wong (1991). A numerical experiment on the relative importance of H_2O_2 and O_3 in aqueous conversion of SO_2 to SO_4^{2-}. Atmospheric Environment 25A(2), 411-423.

[41] Kruse-Plass, M, HM ApSimon, and B Barker (1993). A modeling study of the effect of ammonia on in-cloud oxidation and deposition of sulphur. Atmospheric Environment 27A(2), 223-243.

[42] Final C5-PSD Permit Application, RK & Associates, Inc. 7/30/07 revision. p. 40

species.[43] Thus we do not expect conditions such as those reported for the more extreme conversion rates in the field-study literature.[44]

The field studies on acid fog display a wide range of conversion rates, ranging from negligible[45] up to 40%/h.[46] As a realistic estimate of the conversion rate in a rural area with some background pollution from regional sources, we consider Klemm et al (1992) observations for coastal New England fog as the most representative source. For higher SO_2 values, the overall oxidation capacity for SO_2 was <2%/hr. As an upper bound for our realistic estimate, based on professional judgment and desire to be conservative, we use a conversion rate of 10%/hr.[47] Resulting $SO_4^=$ concentrations in liquid water of mist or fog are shown in Figure 17.

4.2.6.   *Worst-Case Modeled Acid Fog pH*

The distribution of pH values attained during fog or mist events in 2002-2006 is shown in Figure 18, and co-occurrence of pH values attained with event durations are shown in Figure 19.

Benchmark fog pH values (i.e., threshold pH levels below which *adverse* effects are observed) are subject to some uncertainty. For example, in at least one case, plants and their insect larvae consumers were shown to have significantly *increased* growth under exposure to low pH fogs.[48] NAPAP (1991) states:

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[43] Ibid., p. 50

[44] Prime example being Eatough et al (1984) (see note 47)

[45] Gervat, GP, PA Clark, ARW Marsh, I Teasdale, AS Chandler, TW Choularton, MJ Gay, MK Hill, and TA Hill (1988). Field evidence for the oxidation of SO_2 by H_2O_2 in cap clouds. Nature 333, 241-243.

[46] Klemm et al, 1992, found this in one case with a SO_2 mixing ratio of <1 ppb. From our perspective this is a degenerate case since the ratio of SO_2 to oxidant was exceptionally low compared to the case of this analysis, since we are explicitly restricting our focus to the high SO_2 case. Upper end conversion rates of 34%/hr have been observed in urban plumes laden with oxidants (Eatough et al, 1984), but such conditions are not appropriate for estimating the oxidative capacity of the atmosphere in the Hennepin, IL area.

[47] For completeness, we will also include an unrealistic scenario using the upper bound 34%/hr conversion rate found by Eatough et al (1984) in an oil-fired power plant plume in a fog bank off the south-central coast of California, where co-emitted oxidants were postulated to cause an extremely high conversion rate and, moreover, inversions and re-circulations are common and contribute to the region's famous atmospheric pollution problems.

[48] Trumble, JT and JD Hare (1989). Acidic fog-induced changes in host-plant suitability: interactions of *Trichoplusia ni* and *Phaseolus lunatus*. Journal of Chemical Ecology 15(9), 2379-2390. See annotated bibliography of literature review results, Appendix A.

The threshold fog pH levels causing visible injury to plant leaves or fruit ranges from pH 1.6 to pH 2.6.... The threshold pH resulting in growth or yield impacts is either the same or lower than that causing visible injury.[49]

For the purposes of conservatively assessing ecological harm (such as growth impacts), we take pH 2.6 as a benchmark for potential degradation of habitat or vegetation health. With this benchmark, it is important to consider the duration of the acid fog or mist event so that total exposure may be accurately assessed.

Figure 19 shows that the vast majority of fog events, particularly those of long duration, are predicted to have inconsequential pH changes resulting from WMH-related emissions. In the majority of cases, a decrease of less than 0.2 pH units is predicted due to total WMH emissions. The benchmark of pH 2.6 is predicted to be "exceeded" for only one hour over the entire 5-year modeling period.[50] Such a singular and short-term event is not likely to cause harm. The study cited in NAPAP (1991, Table 18-25, Tiny Tim tomatoes), where injury at fog pH 2.6 was reported, involved 4 events of 2-hour fogs. Particularly considering the conservative regional background pH value used, the high assumed conversion rate, evaluation at the worst-case habitat location, and inclusion of all WMH emissions in the analysis, potential acid fog events due to SO_2 emissions from WMH are not cause for worry. Overall, the acid fog analysis concludes that near-field acid fog or mist patterns with potential to degrade endangered species habitat are not expected to occur due to WMH emissions.

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[49] U.S. National Acid Precipitation Assessment Program (1991), Acidic Deposition: State of Science and Technology, Volume III: Terrestrial, Materials, Health and Visibility Effects. Effects of Pollutants on Vegetation, p. 18-124.

[50] For completeness, the model was re-run under the upper bound, unrealistic case of 34%/hr conversion. In this case, the estimated frequency of fog or mist events with average pH less than 2.6 was only one such event per year, always lasting only one hour.

31
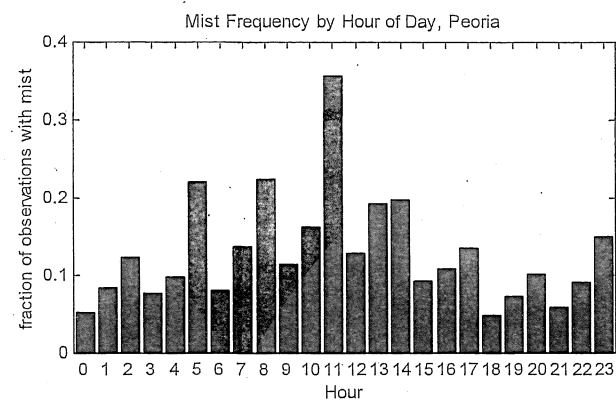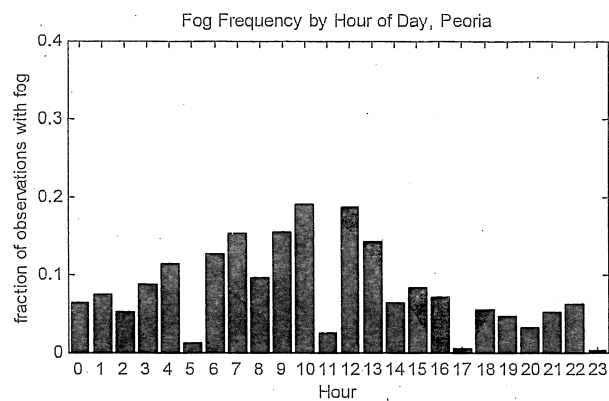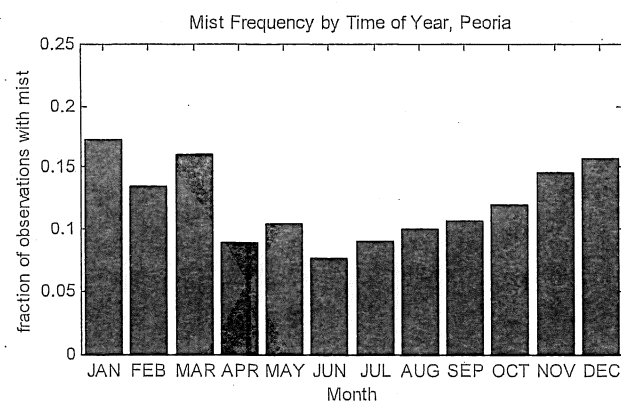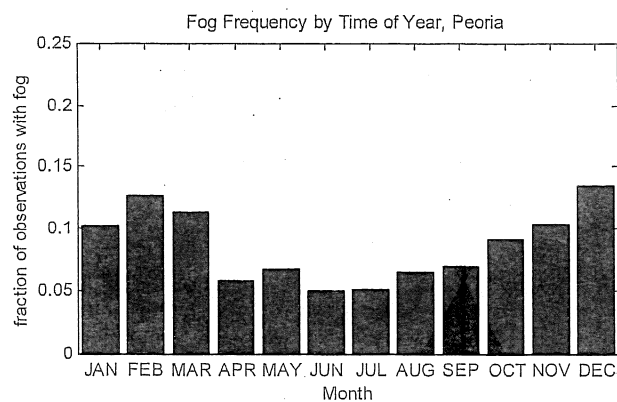
Figure 9   Fog and mist frequency by time of year and time of day, from Peoria Airport observations, 2002-2006.

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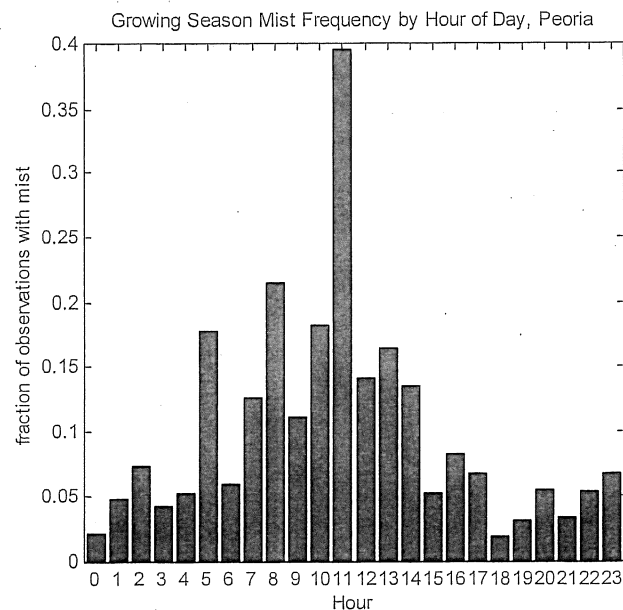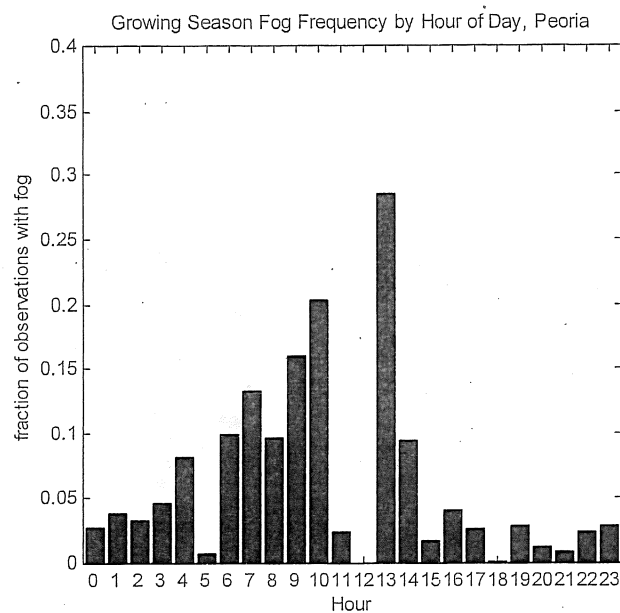
Figure 10 Frequency of observing fog and mist by time of day during the growing season (May – September), from Peoria Airport observations, 2002-2006.

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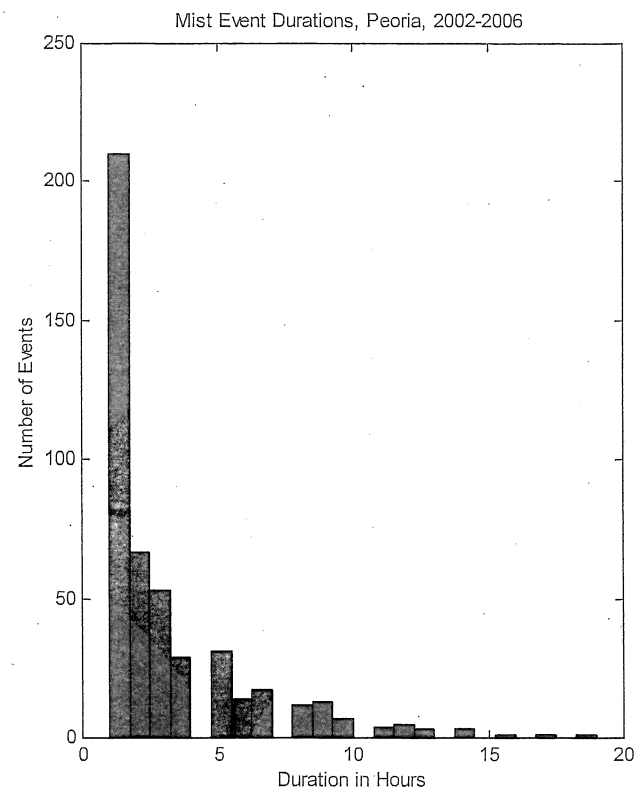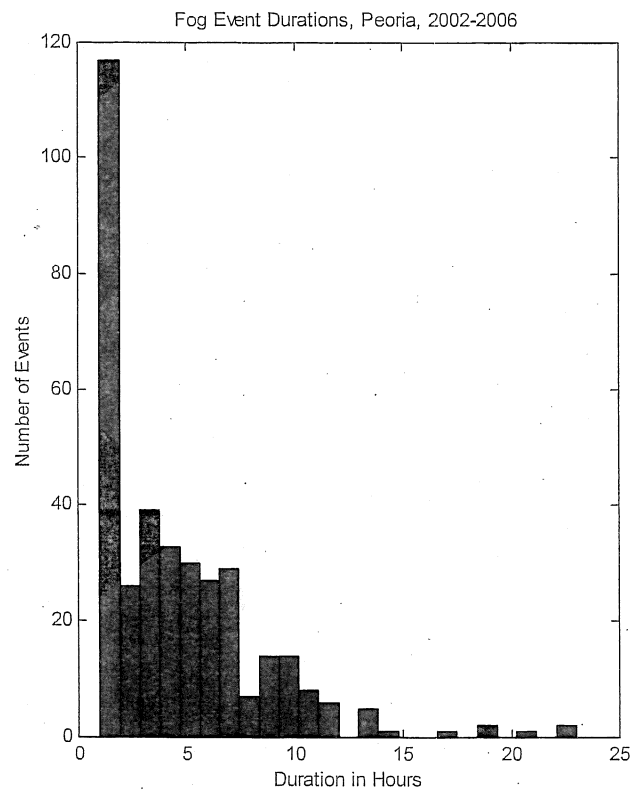
Figure 11   Fog and Mist Event Durations, growing season only, from Peoria Airport observations, 2002-2006.

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AERMOD 3-Hour Maximum SO₂ Concentrations

- · min
- ● max

— Maximum Impact
Ecological Receptor

○ Thermal Oxidizer

200 0 200 400 600 800 1000 1200 1400 1600 Meters
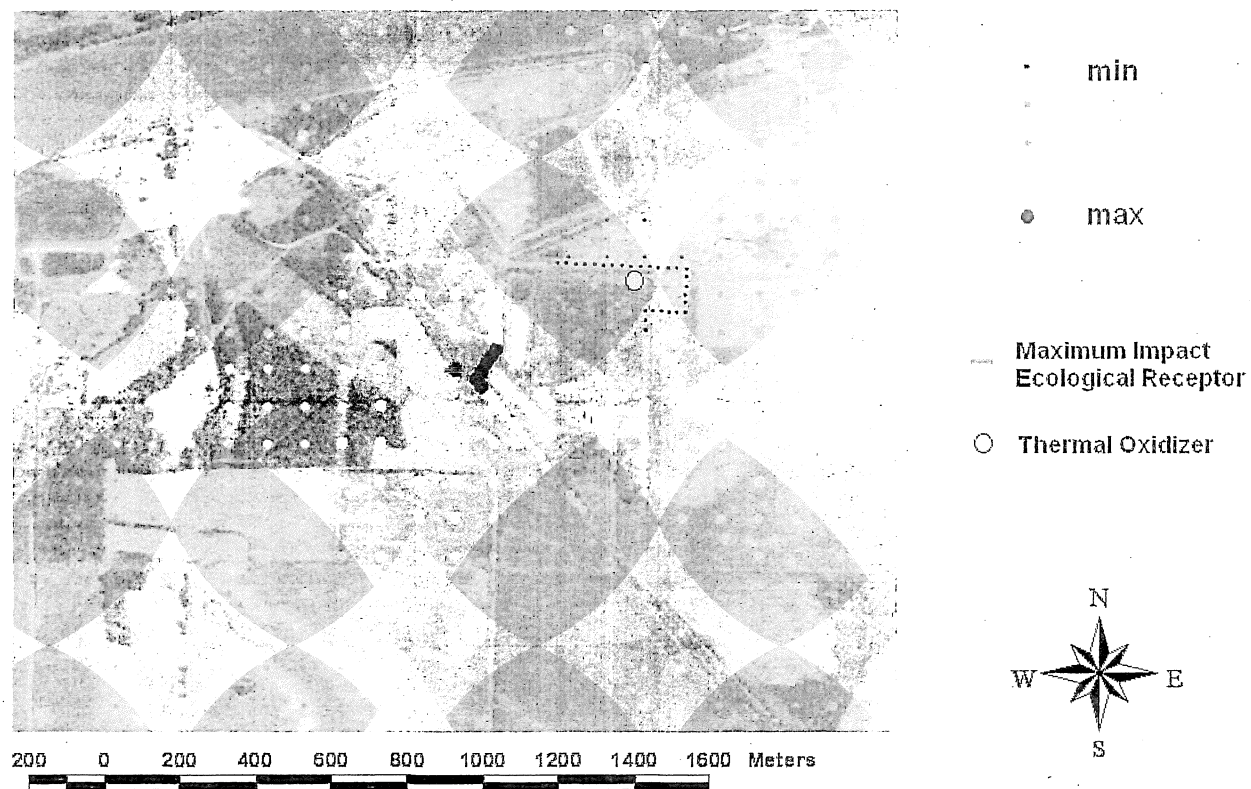
Figure 12 Selection of the maximum impact ecological receptor to use for acid fog analysis, showing distance from thermal oxidizer stack and aerial imagery of WMH and immediate vicinity.
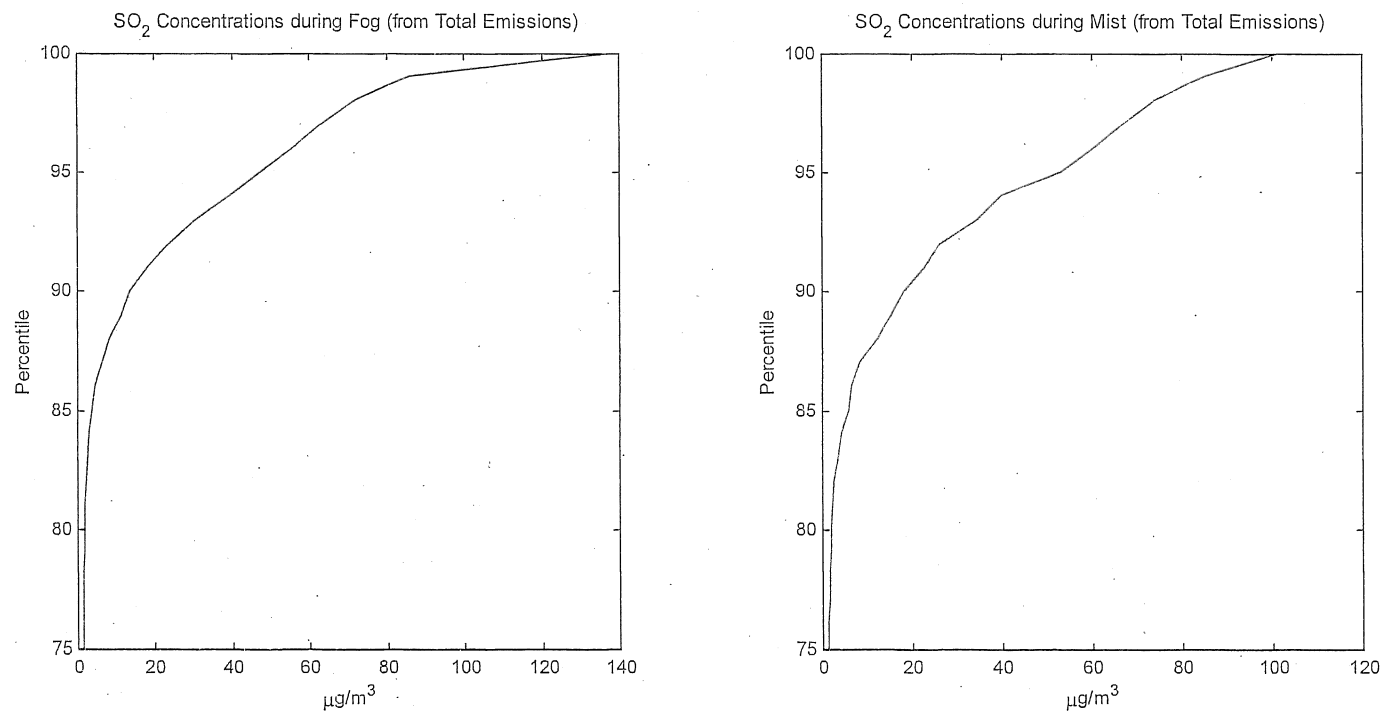
Figure 13 Upper quartile hourly SO$_2$ concentrations during Fog and Mist at selected high-impact ecological receptor, as modeled by AERMOD with total WMH emissions (including present emissions as well as emissions due to proposed expansion).

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Background pH Monitoring Sites
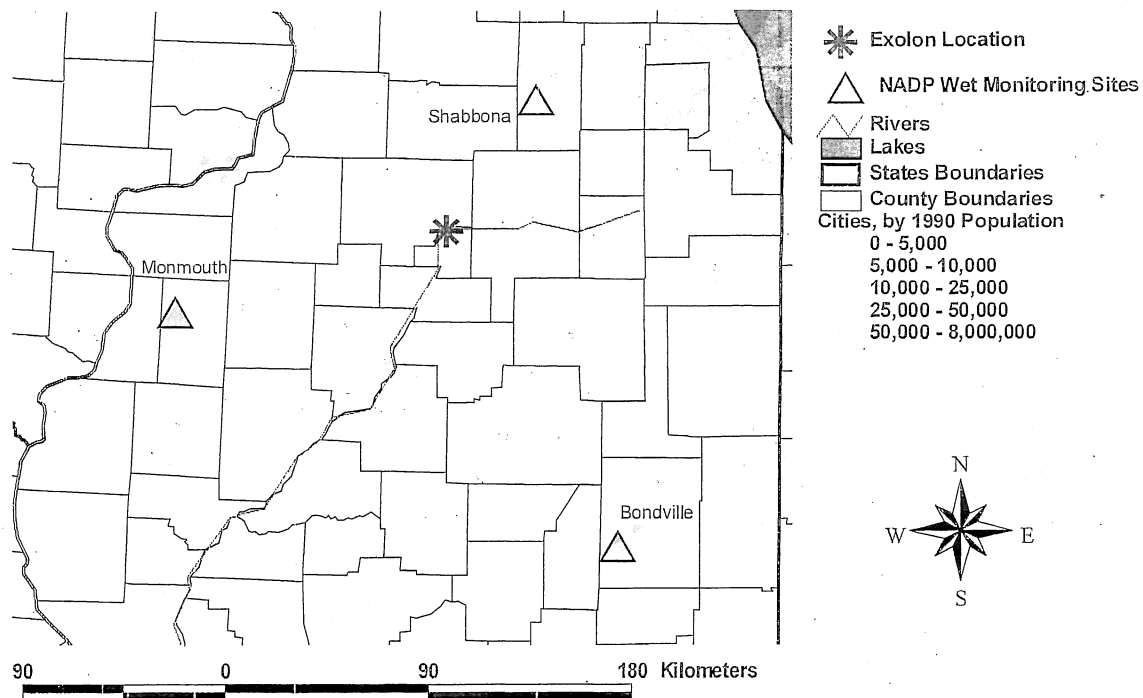
Figure 14   The three nearest NADP wet monitoring site locations to WMH are Monmouth, Shabbona, and Bondville.

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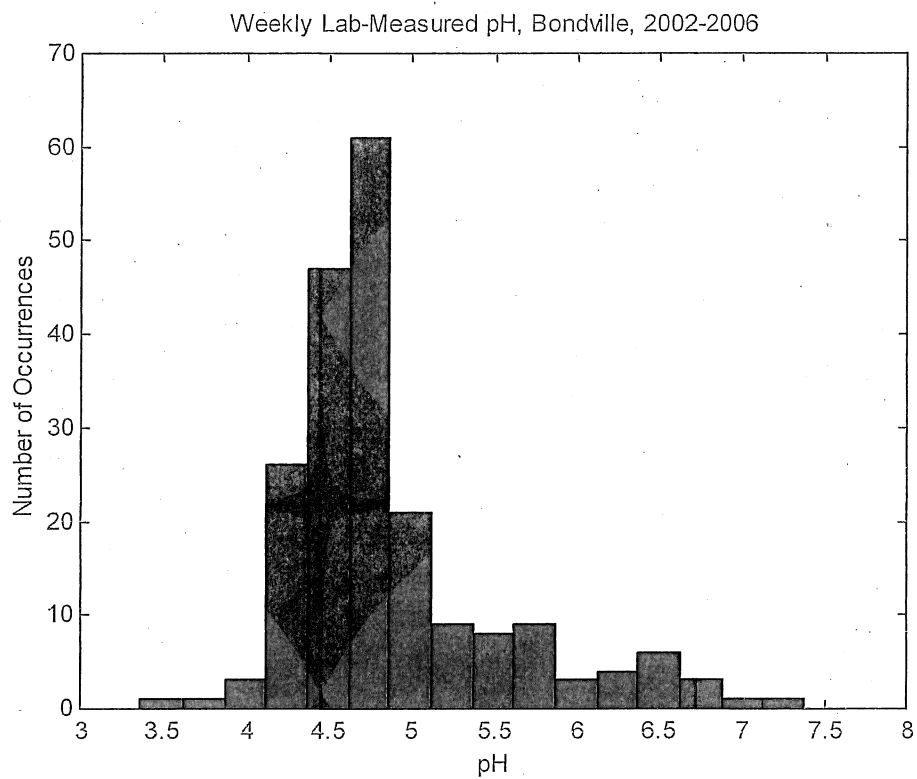
Figure 15 The distribution of weekly pH values attained over the 5-year modeling period at the Bondville background monitoring site. Minimum: 3.6, Mean: 4.9
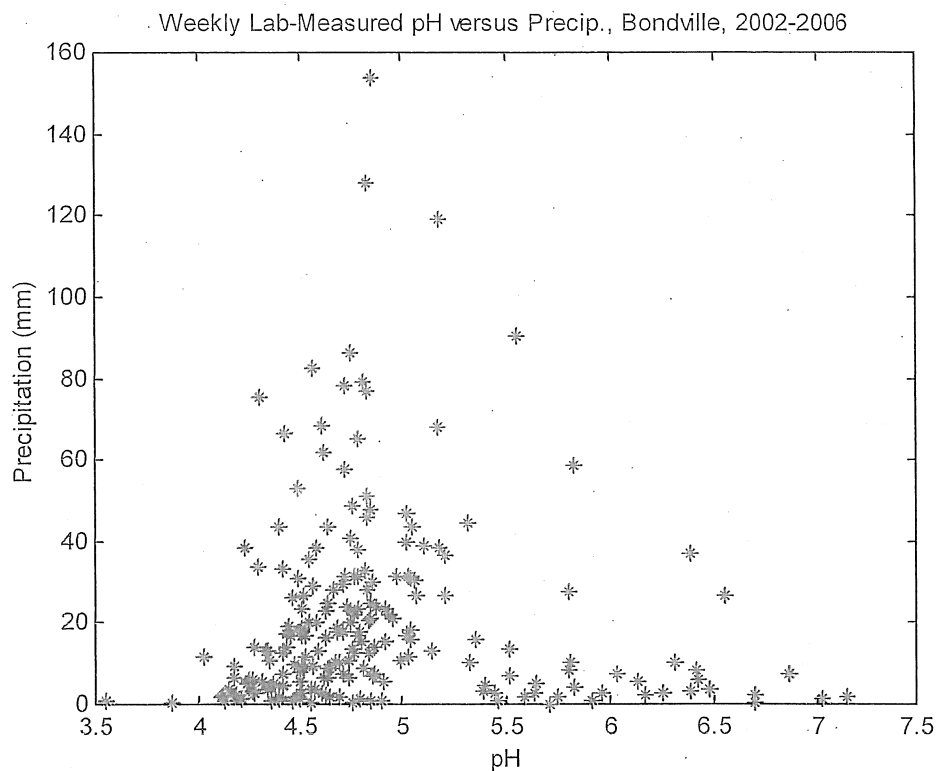
Figure 16 Scatterplot of co-occurrence of weekly pH with weekly precipitation. Extreme high or low pH values tend to occur with extremely low precipitation, such as may occur via fog, mist, or drizzle, although most weeks of low precipitation do not have extreme pH.
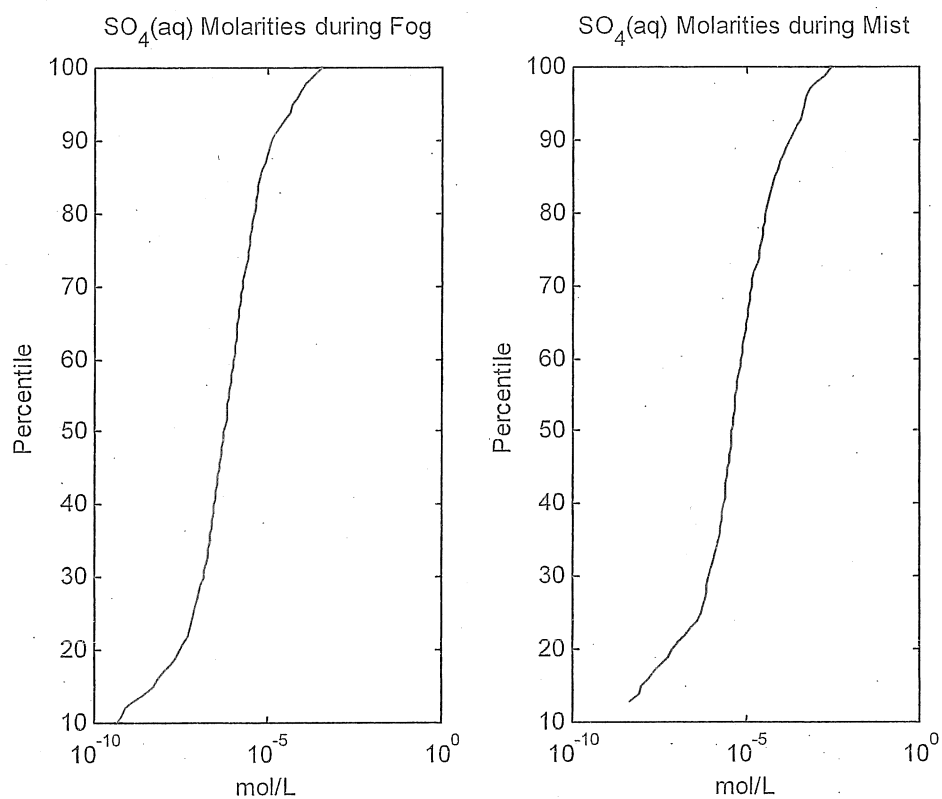
Figure 17 Acid fog model results: distributions of SO₄ concentrations in fog and mist water, from
starting pH = 3.6 and SO₂ conversion rate of 10%/hr. Note semilog scale on x-axis.
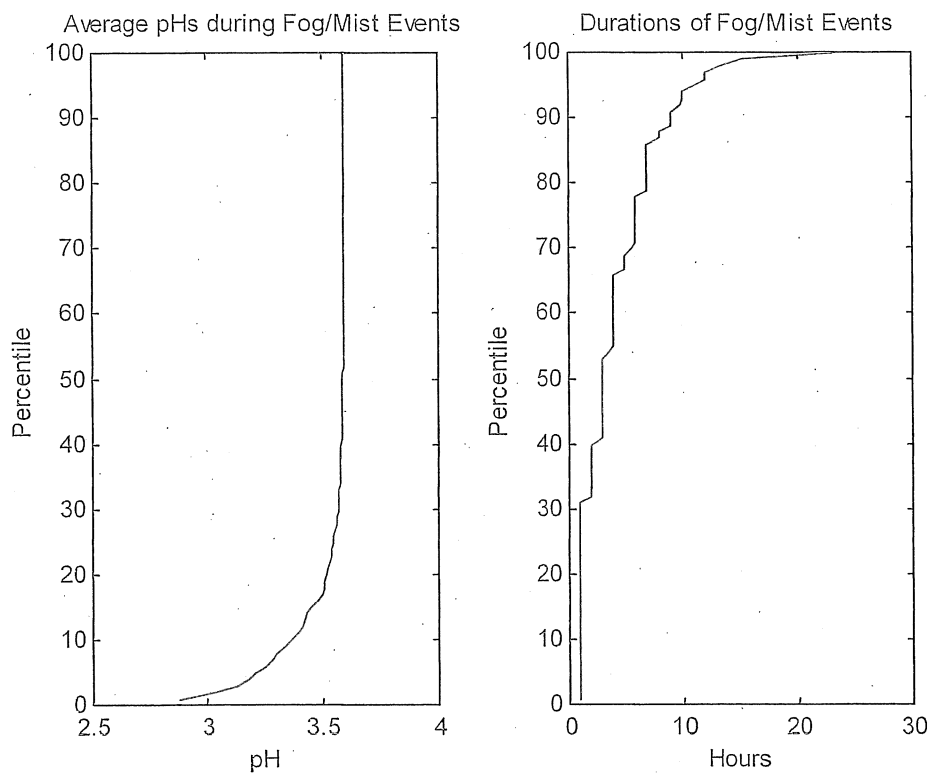
Figure 18   Acid fog model results: Distributions of event-averaged pH for all fog or mist events 2002-2006 and of their durations, from starting pH = 3.6 and SO_2 conversion rate of 10%/hr.

Fog/Mist Event Average pH by Event Duration
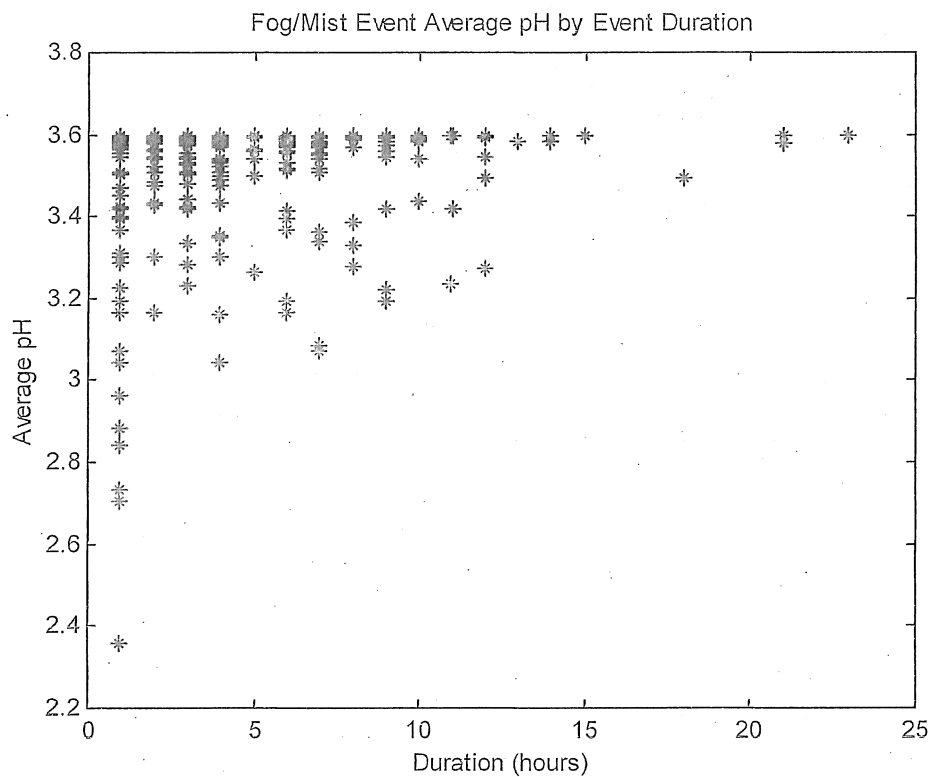
Figure 19 Acid fog model results: Scatterplot of event-averaged pH and fog/mist event duration for all events 2002-2006, from starting pH = 3.6 and SO_2 conversion rate of 10%/hr. Note that all events with pH < 3 last only one hour.

5. Long-term Impacts Assessment

Three types of potential long-term impacts to threatened and endangered species are evaluated: chronic toxicity from increases in atmospheric concentrations of various chemicals, accumulation of metals in soil and sediment, and food chain effects via bioaccumulation-based toxicity of metals to the Indiana bat.

5.1. Chronic Effects

Chronic effects are considered which could result from increases in atmospheric concentrations on an annual time scale. Hazardous air pollutants emitted from WMH (carbon disulfide, carbonyl sulfide, formaldehyde, and hexane) are considered, as well as potentially toxic metals present in particulate emissions. Hydrogen sulfide is also considered, since it is a biologically active gas which may affect both plant and animal health if present in sufficiently large concentrations.

Increments of annually averaged atmospheric concentrations due to the proposed fifth furnace at WMH are compared to background concentrations in Table 4. Background data was taken from EPA sources, with the exception of carbonyl sulfide, for which representative background concentrations were found in the literature.[51] No chemicals of concern show appreciable increases over background (all increases were 10% or less).

For consideration of more subtle ecosystem-level effects, we turn to the WHO air quality guidelines for Europe. For sulfur dioxide, the guideline critical level to protect forests and natural vegetation in areas with harsh winters is 15 $\mu g/m^3$. The background level in this area of Illinois is about 10.5 $\mu g/m^3$ and the worst-case incremental WMH impact is only 0.5 $\mu g/m^3$, thereby leaving the total impact below even this most protective standard. For nitrogen oxides, the WHO European critical level is 30 $\mu g/m^3$, while background level is around 12 $\mu g/m^3$ and the worst-case impacts from proposed WMH expansion are only 0.04 $\mu g/m^3$, leaving the total impacts well below the most protective threshold for nitrogen oxides.

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[51] Montzka, SA, P Calvert, BD Hall, JW Elkins, TJ Conway, PP Tans, and C Sweeney (2007). On the global distribution, seasonality, and budget of atmospheric carbonyl sulfide (COS) and some similarities to CO_2. Journal of Geophysical Research 112, doi:10.1029/2006JD007665

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5.2.   *Accumulation of Metals*

5.2.1.   *Soil modeling and comparisons*

Concentrations of most COPCs in soil are estimated with a simple mixing model that assumes pollutants deposit from the atmosphere over a period of one hundred years of facility operation and remain within a shallow layer of soil near the surface. This soil deposition/concentration model is recommended in the U.S. EPA's multi-pathway risk assessment protocol guidance for untilled soils. The potential increase in pollutant concentration in soil is predicted by the following equation:

$$C_{HAPsoil} = \frac{D_{HAP} T_{Exo}}{d_{soil} \rho_{soil}}$$

Equation 4

where the terms are:

$C_{HAPsoil}$	Concentration, or mass fraction, of the HAP in soil (mg/kg);
D_{HAP}	HAP deposition rate estimated by air dispersion/deposition modeling (mg/m²–year);
T_{Exo}	Years of operation of the proposed WMH expansion;
d_{soil}	Depth of the shallow soil layer (m); and
ρ_{soil}	Bulk density of soil (kg/m³).

Parameter values recommended by EPA, and used in applying the model, are: an untilled soil mixing depth d_{soil} of 2 cm (0.02 m), a soil bulk density ρ_{soil} of 1.5 g/cm³ (1500 kg/m³), and a facility operating period T_{Exo} of 100 years.[52] The untilled soil depth reflects an unmixed surficial deposition layer into which contaminants that strongly adhere to soil may accumulate. Additionally, the model assumes that pollutants stay within the shallow soil mixing zone, and does not take account of loss terms such as leaching that are recommended by EPA in more sophisticated soil models.

Benchmark concentrations are selected from a hierarchy of sources to identify HAP concentrations in soils that are not toxic or detrimental to vegetation:

- U.S. EPA Ecological Soil Screening Level (Eco-SSL) for Plants, consensus-based values based on in-depth literature reviews (http://www.epa.gov/ecotox/ecossl/);
- U.S. EPA Region 5 Ecological Screening Level (applicable to different categories of environmental receptors, based on HAP-specific data availability, available at: http://www.epa.gov/reg5rcra/ca/ESL.pdf); and
- Lowest value benchmark for soil (irrespective of target ecological endpoint) available in the ORNL Risk Assessment Information System (http://rais.ornl.gov/).

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[52] U.S. EPA (2005). Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. EPA530-R-05-006.

44

Modeled worst-case concentrations in soil are presented along with representative background concentrations and relevant ecological benchmarks for comparison in Table 5. All three metals are shown to have low incremental accumulations relative to background soil concentrations (a few percent at most).

In the case of vanadium, the background soil concentration (generic for all rural counties in Illinois) exceeds the Region 5 ESL benchmark substantially. However, the contribution of predicted impacts from the proposed WMH expansion are not significant relative to background levels, and the benchmark for the Indiana bat (mammals) is not approached.

5.2.2. Surface water modeling and comparisons

The screening-level model to estimate worst-case concentrations in surface water assumes that all emissions are mixed into the Illinois River. This is an extremely conservative model, as it assumes that 100% of pollutant emissions deposit into the Illinois River watershed and enter the river. This model is used as an initial screening tool to evaluate the potential for significant loading of metals to surface waters.

Worst-case screening-level concentrations in water are calculated by dividing the emission rate of each metal (see Table 2) by the long-term average streamflow rate of the Illinois River, which is about 15,650 cfs.[53] Surface water concentrations of contaminants calculated by the simple mixing model are available in Table 6 along with background concentrations. Background concentrations are based on 15-18 years (1980 or 1983 to 1998) of historical IEPA measurements of the Illinois River at Hennepin, and represent averages of 151 or 134 samples. Ecological screening benchmarks are also provided for comparison.

The surface water analysis shows that worst-case metal loading to surface water will be very small fractions (<<0.01%) of background concentrations in surface water. In the case of aluminum, the background level significantly exceeds the benchmark found for the most sensitive species; however, impacts resulting from proposed WMH expansion are predicted to not contribute significantly.

5.2.3. Sediment modeling and comparisons

Sediment concentrations are evaluated under the assumption that the whole of pollutant emission increases from the proposed WMH expansion enter the Illinois River, become mixed with suspended sediment in the river, and then deposit to form bed sediment

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[53] Average of all mean daily streamflow data collected by Illinois EPA at the surface water station "Illinois River at Hennepin," 1977-1991 (108 samples). Data downloaded from EPA STORET Legacy Data Center, http://www.epa.gov/storpubl/legacy/gateway.htm (last accessed 12/2007).

45

within the Illinois River valley. As in the surface water model, this simple model will greatly overestimate pollutant concentrations in sediments as it assumes that all emissions deposit in the Illinois River watershed and enter the river. Concentrations in sediment are calculated as the pollutant emission rate divided by the average annual sediment deposition (sediment inflow from tributaries minus sediment outflow at Valley City) in the Illinois River valley, which is about 6.7 million tons.[54]

Results are shown, together with ecological benchmarks (where available), in Table 7. The sediment analysis shows that metal loading to sediments will be very small fractions (<<0.01%) of background concentrations in sediments. For nickel, the background level exceeds benchmark, but as in the surface water case, this cannot be attributed to effects of the facility since only miniscule increments are predicted due to proposed WMH expansion. No background or benchmark was found for vanadium.

5.2.4.   *Food chain analysis for Indiana bat*

The purpose of a food chain analysis for a higher trophic level species such as the Indiana bat is to assess the bioaccumulation effects which can occur after biological uptake from soil, sediment, or surface water. There are certain conditions necessary for adverse food chain effects to happen. For example, there must be an initial exposure low on the food chain to a toxic substance. Then, the substance must have a tendency to be stored in an organism's tissues and passed on to whatever eats it. In this manner, plants and herbivores may accumulate the toxic substances in their tissues. The levels may not be high enough to harm the plants or herbivores, but when omnivores and higher carnivores consume the tissue of the lower food chain species, they can accumulate far more of the substance in a magnification effect that increases with each link of the food chain. In food chain analyses such as those described in SLERAP,[55] the worst-case resultant levels of a substance in a higher trophic level species is estimated from published food chain multipliers and bioaccumulation factors. When the species of interest is higher on the food chain, the media (e.g. soil, sediment, and surface water) concentrations can magnify in the food chain if chemical tends to bioaccumulate, and hence lead to greater exposure to higher trophic level species.

Taking the three metals in turn, aluminum is not a metal with potential food chain consequences for the Indiana bat. Aluminum, the most commonly occurring metallic element in the Earth's crust, is generally omnipresent in soils, becoming soluble and having the potential to harm plants only under soil pH values of 5.5. There is no

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[54] Source of sediment deposition datum: Demissie, M, R Xia, L Keefer, and N Bhowmik (2004), The sediment budget of the Illinois River. Illinois State Water Survey, Contract Report 2004-13, 52 pp.

[55] U.S. EPA (1999), Screening level ecological risk assessment protocol for hazardous waste combustion facilities. Peer review draft. EPA530-D-99-001A

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correlation between total aluminum concentration and ecological impact.[56] Therefore incremental food chain impacts from aluminum deposition due to the proposed WMH expansion are not necessary to consider.

For nickel, a bioaccumulation summary for wildlife and aquatic organisms was available.[57] The summary states that "food chain multipliers for nickel in wildlife were not found in the literature" and that "little evidence exists to support the general occurrence of biomagnification of nickel in the aquatic environment."[58] Moreover, the mammalian ecological soil screening level (Eco-SSL) for nickel[59] is 130 mg/kg dry weight in soil, exceeding the background soil concentration by a factor of 10. Considering these findings along with the factor 0.02 increase over background predicted as the maximum possible impact from proposed WMH expansion, and the miniscule increases predicted for surface water and sediment, there are no food chain impacts expected for nickel.

Finally, for vanadium, no bioaccumulation summary was available. The mammalian Eco-SSL for vanadium[60] of 280 mg/kg dry weight is more than a factor 10 over background, with predicted maximum WMH increments of factor 0.002 over background. Therefore, like nickel, no food chain impacts are expected.

Overall, considering both lack of evidence for biomagnification and total soil levels far below available mammalian Eco-SSLs, food chain impacts for the Indiana bat due to proposed WMH expansion are not predicted.

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[56] U.S. EPA (2003), Ecological soil screening level for aluminum: interim final. OSWER Directive 9285.7-60

[57] U.S. EPA (2000), Bioaccumulation testing and interpretation for the purpose of sediment quality assessment: status and needs. EPA-823-R-00-001

[58] Ibid., Bioaccumulation summary: Nickel.

[59] U.S. EPA (2007), Ecological soil screening level for nickel: interim final. OSWER Directive 9285.7-76

[60] U.S. EPA (2005), Ecological soil screening level for vanadium: interim final. OSWER Directive 9285.7-75

Table 4   Chronic concentrations of all chemicals of concern relative to background

Chemical of Concern	Incremental emission rate (tons/year)	Projected increment due to proposed WMH expansion ($\mu g/m^3$)	Background concentration ($\mu g/m^3$) [A]	Ratio: Projected increase to background
Hydrogen sulfide (H_2S)	1.49	1.61E-03	1.50E+00 [B, E]	0.001
Carbonyl sulfide (COS)	1.87	2.02E-03	1.21E+00 [C]	0.002
Carbon disulfide (CS_2)	1.12	1.21E-03	8.87E-02	0.01
Sulfur dioxide (SO_2)	507.38	5.47E-01	1.05E+01 [G]	0.05
Nitrogen oxides (NO_x)	39.58	4.27E-02	1.20E+01 [H]	0.004
Formaldehyde	0.0107	2.62E-02	2.99E-01	0.09
Hexane	0.258	1.15E-05	5.07E-02	0.0002
Aluminum (Al) [F]	0.0008	1.40E-04	2.53E-02 [D, E]	0.006
Nickel (Ni) [F]	0.0002	3.34E-05	1.17E-03 [D, E]	0.03
Vanadium (V) [F]	0.0005	9.24E-05	2.43E-03 [D, E]	0.04

Notes:

A   Modeled background estimate from the U.S. EPA's 1999 National Air Toxic Assessment for the census tract in which WMH is located, unless otherwise specified. Data available at: http://www.epa.gov/ttn/atw/nata1999/tables.html

B   Average level detected at eleven monitoring locations in Iowa and Missouri in 2006. Concentrations at these sites vary over a narrow range, from 1.4 $\mu g/m^3$ to 1.7 $\mu g/m^3$.

C   Average level detected from submonthly ground-level ambient air measurements at Niwot Ridge, CO, between 2000 and 2007. Level agrees with Northern Hemisphere average to one significant figure (494 ppt at Niwot Ridge vs. 476 ppt over NH). Source: Montzka et al, 2007.

D   Average levels detected at six monitoring locations in Illinois in 2006, based on chemical speciation analyses of $PM_{2.5}$ measurements. Concentrations varied by less than a factor of two across locations. Ranges of 0.020–0.031 $\mu g/m^3$, 0.0009–0.0016 $\mu g/m^3$, and 0.002–0.003 $\mu g/m^3$, were measured for Al, Ni, and V, respectively.

E   Data obtained from the U.S. EPA's AirData website (http://www.epa.gov/air/data/) that provides on-line access to its Air Quality System database. Accessed December 21, 2007.

F   Incremental emission rates are based on the sum of particulate contributions from coke- and silicon carbide-related sources. The fractions of metals in the sources are based on measured compositions of coke and silicon carbide product (SCP). Coke contains average Al, Ni, and V mass fractions of 0.0006, 0.0002, and 0.0003, respectively. SCP contains an average mass fraction of 0.0005 of both Al and V.

G   Annual mean from Illinois EPA (2006), Illinois Annual Air Quality Report 2005, Oglesby.

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H	An average concentration of 0.0063 ppm (12 ug/m3) of NOx was measured at Braidwood, IL over the period from April 11, 2006 to September 26. 2006 (3953 hourly observations). Data downloaded from the U.S. EPA's Air Quality System database (http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm).

Table 5   Soil accumulation of metals and comparison to background

Chemical of Concern	Projected deposition rate increment due to proposed WMH expansion (g/m^2/year) [A]	Projected soil loading increment due to proposed WMH expansion (mg/kg)	Background concentration in soil (mg/kg) [B]	Ratio: Projected increase to background	Ecological benchmark for soil (mg/kg) [C]
Aluminum (Al)	2.65E-04	8.85E-01	9200	0.0001	n/a [D]
Nickel (Ni)	5.47E-05	1.82E-01	13	0.01	38 (plants); 130 (mammals)
Vanadium (V)	1.89E-04	6.31E-01	25	0.03	1.59 [E] (plants); 280 (mammals)

Notes:

A   Incremental emission rates are based on the sum of particulate contributions from coke- and silicon carbide-related sources. The fractions of metals in the sources are based on measured compositions of coke and silicon carbide product (SCP). Coke contains average Al, Ni, and V mass fractions of 0.0006, 0.0002, and 0.0003, respectively. SCP contains an average mass fraction of 0.0005 of both Al and V.

B   Data provided by the Illinois Administrative Code, Title 35, Part 742, Table G, "Concentrations of Inorganic Chemicals in Background Soils." Values are for counties outside Metropolitan Statistical Areas.

C   Source, unless otherwise noted: U.S. EPA, Ecological Soil Screening Levels.

D   As per the discussion in the U.S. EPA Eco-SSL document for Aluminum, no number is cited because aluminum toxicity in soil is not based on total aluminum concentration, but rather on soil pH. See further discussion in Section 5.2.4.

E   Since no vanadium Eco-SSL for plants is available, the value from EPA, Region 5, RCRA Ecological Screening Levels is used, http://www.epa.gov/reg5rcra/ca/edql.htm (last accessed 12/2007). This value was found to be lowest ecological benchmark available for soil on the ORNL Risk Assessment Information System (http://rais.ornl.gov/homepage/benchmark.shtml).

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Table 6   **Surface water accumulation of metals and comparison to background**

Chemical of Concern	Projected surface water loading increment due to proposed WMH expansion (μg/l)	Background concentration in surface water (μg/l) [A]	Ratio: Projected increase to background	Ecological benchmark for surface water (μg/l) [B]
Aluminum (Al)	4.97E-05	934	0.0000001	75 [C]
Nickel (Ni)	1.31E-05	13	0.000001	28.9
Vanadium (V)	3.07E-05	5	0.000006	12

Notes:

A   Average of total concentration data collected by Illinois EPA at the surface water station "Illinois River at Hennepin." Data downloaded from EPA STORET Legacy Data Center, http://www.epa.gov/storpubl/legacy/gateway.htm (last accessed 12/2007).

B   Source, unless otherwise noted: U.S. EPA Region 5, RCRA Ecological Screening Levels (ESLs) for surface water, http://www.epa.gov/reg5rcra/ca/edql.htm

C   No benchmark was available from Region 5 ESLs for surface water. 0.075 mg/L (EC20 Sensitive Species Surface Water Screening Benchmark) was the lowest benchmark available on ORNL RAIS. Reference: Suter, GW (1996), II. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxic. Chem. 15:1232-1241.

Table 7   Sediment accumulation of metals and comparison to background

Chemical of Concern	Projected sediment loading increment due to proposed WMH expansion (μg/kg)	Background concentration in sediment (μg/kg) [A]	Ratio: Projected increase to background	Ecological benchmark for sediment (μg/kg)
Aluminum (Al)	1.14E-01	5.30E+07	0.000000002	7.32E+07 [B]
Nickel (Ni)	3.00E-02	3.30E+04	0.0000009	2.27E+04 [C]
Vanadium (V)	7.06E-02	n/a	n/a	n/a [D]

Notes:

A   Median (Percentile 50) element concentration for high-order streams taken from Colman, JA and RF Sanzolone (1992), Geochemical characterization of streambed sediment in the Upper Illinois River Basin. Water Resources Bulletin 28(5), 933-950. Table 4 cites 5.3 percent aluminum concentration on dry-weight basis and 33 μg/g for nickel.

B   No sediment benchmarks for aluminum were available from Region 5 ESLs. Value cited is the lowest available ecological benchmark on ORNL RAIS for aluminum in sediment: ARCS NEC Sediment Screening Benchmark, 73200 mg/kg. Reference: U.S. EPA (1996), Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008.

C   Source: U.S. EPA Region 5, RCRA Ecological Screening Levels (ESLs) for sediment, http://www.epa.gov/reg5rcra/ca/edql.htm

D   There were no sediment benchmarks for vanadium on ORNL RAIS.

6. Conclusions

This Ecological Screening Evaluation predicts that pollutant emissions from the proposed expansion of the Washington Mills Hennepin, Inc. (WMH) facility will not adversely affect threatened and endangered species. A habitat analysis indicates that while there are no known occurrences of threatened and endangered species near the WMH facility at present, land use and vegetation conditions could potentially support some federally listed plant species as well as the Indiana bat.

At the most basic level, pollutant concentrations in air are expected to be increased only small amounts above existing background levels. None of the pollutants are known to adversely affect plant species at the anticipated concentrations (facility impacts plus background) either by direct phytotoxicity or by more subtle changes that might influence the structure of plant communities. Additional consideration of the deposition of pollutants likely to deposit to soil, surface water, and sediment finds levels that are at most small fractions of existing background, even based on conservative models likely to overpredict actual impacts (possibly by large margins), and all of the modeled impacts are also smaller than screening-level ecological benchmarks. Additional qualitative consideration of food chain pathways indicates that pollutant emissions from the WMH facility are not likely to bioaccumulate in the environment or lead to greater exposure levels in the diets of higher trophic species such as the Indiana bat.

An acid fog analysis was developed to assess the possibility that emissions of sulfur dioxide (the pollutant released in the greatest amount by the WMH facility) might produce low-pH fog or mist that could damage endangered plant species. Starting with the assumption of low-pH background conditions, a dispersion modeling analysis combined with concurrent dataset of fog occurrence was used to predict the magnitude and frequency of potential low-pH fog-water exacerbations by WMH emissions. In most cases, hourly decrements to fog-water were less than 0.2 pH units lower than the assumed background pH of 3.6. Over a five-year simulation period, one "worst-case" hourly pH value was predicted to be smaller than the estimated benchmark level of 2.6 necessary to cause damage to vegetation. However, even this singular condition would not be expected to harm threatened and endangered species, as the effects threshold level is based a considerably longer period of exposure.

In summary, we do not expect that proposed increases in emissions from the WMH facility will adversely impact threatened and endangered species in the area.

Appendix A. Literature Review

An extensive literature search was conducted for issues relating the effects of significant WMH air pollutants to the listed species, as well as to species important to the recovery of listed species.

Searches were conducted for combinations of terms as described below. The terms were searched for within abstracts rather than as specific keywords or title words. All searches were conducted within BIOSIS Previews, the premier online database of life science literature which draws on more than 5,500 sources of journal articles, meeting and conference reports, books, and patents. In our experience, BIOSIS Previews consistently yields more results for biology-related searches than other citation databases such as ISI Web of Science and AGRICOLA.

In general, searches sought a combination of an organism identifier (genus, family, or order) with relation to an air pollution related issue (hazardous air pollutants, etc). As a reminder, species of interest for this report are:

- Indiana bat (genus: Myotis, family: Vespertilionidae)
- Eastern prairie fringed orchid (genus: Platanthera, family: Orchidaceae)
- Prairie bush clover (genus: Lespedeza, family: Fabaceae)
- Decurrent false aster (genus: Boltonia, family: Asteraceae)
- Insect prey of Indiana bats (orders: Coleoptera, Diptera, Lepidoptera, Trichoptera)
- Hawkmoth pollinators of EPF orchid (order: Lepidoptera, family: Sphingidae)

A.1.   Search terms

1. (Myotis or Vespertilionidae) and air pollution
2. (Myotis or Vespertilionidae) and sulfur
3. (Myotis or Vespertilionidae) and acid deposition
4. (Myotis or Vespertilionidae) and particulate matter
5. (Myotis or Vespertilionidae) and hazardous air pollutants
6. (Myotis or Vespertilionidae) and toxicity

7. (Lepidoptera or Sphingidae) and air pollution
8. (Lepidoptera or Sphingidae) and sulfur
9. (Lepidoptera or Sphingidae) and acid deposition
10. (Lepidoptera or Sphingidae) and particulate matter
11. (Lepidoptera or Sphingidae) and hazardous air pollutants
12. (Lepidoptera or Sphingidae) and toxicity

13. Coleoptera and air pollution
14. Coleoptera and sulfur

15. Coleoptera and acid deposition
16. Coleoptera and particulate matter
17. Coleoptera and hazardous air pollutants
18. Coleoptera and toxicity

19. Diptera and air pollution
20. Diptera and sulfur
21. Diptera and acid deposition
22. Diptera and particulate matter
23. Diptera and hazardous air pollutants
24. Diptera and toxicity

25. Trichoptera and air pollution
26. Trichoptera and sulfur
27. Trichoptera and acid deposition
28. Trichoptera and particulate matter
29. Trichoptera and hazardous air pollutants
30. Trichoptera and toxicity

31. (Platanthera or Orchidaceae) and air pollution
32. (Platanthera or Orchidaceae) and sulfur emissions
33. (Platanthera or Orchidaceae) and sulfur deposition
34. (Platanthera or Orchidaceae) and acid deposition
35. (Platanthera or Orchidaceae) and particulate matter
36. (Platanthera or Orchidaceae) and hazardous air pollutants
37. (Platanthera or Orchidaceae) and toxicity

38. (Lespedeza or Fabaceae) and air pollution
39. (Lespedeza or Fabaceae) and sulfur emissions
40. (Lespedeza or Fabaceae) and sulfur deposition
41. (Lespedeza or Fabaceae) and acid deposition
42. (Lespedeza or Fabaceae) and particulate matter
43. (Lespedeza or Fabaceae) and hazardous air pollutants
44. (Lespedeza or Fabaceae) and toxicity

45. (Boltonia or Asteraceae) and air pollution
46. (Boltonia or Asteraceae) and sulfur emissions
47. (Boltonia or Asteraceae) and sulfur deposition
48. (Boltonia or Asteraceae) and acid deposition
49. (Boltonia or Asteraceae) and particulate matter
50. (Boltonia or Asteraceae) and hazardous air pollutants
51. (Boltonia or Asteraceae) and toxicity

A.2. Search Results

In general, there were very few relevant results considering the number of searches. Searches including "toxicity" often yielded at least 100 results, but almost exclusively pertaining to either the efficacy of various insecticides (when searched for with insect names) or the toxicity of oils or other substances derived from plants (when searched for with plant names). Most other plant searches and bat searches yielded no citations, but the insect searches usually had at least a few citations, again mostly pertaining to insecticide development.

A few studies were relevant because they examined effects of acidity on plant or insect populations, either through soil acidity or surface water acidity. Additionally, a few articles pertained to pollution deposition impacts. The relevant results are listed and briefly summarized in the context of this report below.

A.3. Potentially Relevant Work

Bowman, MF, KM Somers, RA Reid, and LD Scott (2006). Temporal response of stream benthic macroinvertebrate communities to the synergistic effects of anthropogenic acidification and natural drought events. Freshwater Biology 51(4), 768-782

Benthic macroinvertebrate communities include *Diptera* and other aquatic insects thought to be favored by the northern Indiana bat. The authors of this study looked at 8 years of stream chemical and biological data. Using a single summary metric of the benthic macroinvertebrate (BMI) community to represent its overall health, they found that BMI health was inversely related to streamwater pH. The study suggests that short-term improvements in BMI health were hampered by drought-induced re-acidification of the streams which led to acid or metal toxicity.

Carbone, J, W Keller, and RW Griffiths (1998). Effects of changes in acidity on aquatic insects in rocky littoral habitats of lakes near Sudbury, Ontario. Restoration Ecology 6(4), 376-389.

Benthic aquatic insect populations from rocky nearshore areas of 17 lakes were assessed over a pH range of 4.3-7.3. Although several species from the *Ephemeroptera* family declined below pH 5.5 due to acid toxicity, *Diptera* abundances increased below pH 5.5 due to absence of fish predators from acid lakes. Overall, total species richness did not depend on pH, although community composition varied greatly over the pH range.

Corke, D (1999). Are honeydew/sap-feeding butterflies (Lepidoptera: Rhopalocera) affected by particulate air-pollution? Journal of Insect Conservation 3, 5-14.

The author notes that causal mechanisms relating air pollution and butterfly declines are unclear, since some species of Lepidoptera are known to exist long-term in heavily smoke-polluted habitats. Nectar, the food source for most adult Lepidoptera, contains no direct airborne deposits. The study then focuses on the type of butterfly feeding which may expose it to air pollution: feeding on honeydew and sap that coats the leaves and bark of trees. Predictions are made based on the hypothesis that particulate deposition adversely affects this type of butterfly.[61]

Dosdall, LM, R-C Yang, and PM Conway (2002). Do applications of sulfur or sulfate influence infestations of root maggots (Delia spp.) (Diptera: Anthomyiidae) in canola? Canadian Journal of Plant Science 82(3), 599-610.

The authors conclude that sulfur application alone will not greatly reduce Diptera larvae infestations in canola crops. By implication, pollutant sulfur deposition to the soil would probably not significantly affect Diptera populations.

Felten, V, and F Geurold (2006). Short-term physiological responses to severe acid stress in three macroinvertebrate species: a comparative study. Chemosphere 63(9), 1427-1435.

The authors looked at three freshwater invertebrate species, including one from the *Trichoptera* family. Among the three, the Trichoptera had intermediate sensitivity to exposure to pH 4.73 natural acidified water for 24, 72, and 120 hours. General results showed significant decreases in survival rates and haemolymph ions as a result of exposure. The results suggest that even transient acidification can negatively impact sensitive macroinvertebrate communities recovering from stream acidification.

Jo, J, S Yoshida, and R Kayama (1980). Growth and nitrogen fixation of some leguminous forages grown under acidic soil conditions. Grassland Science 25(4), 326-334.

10 leguminous forages, including common *Lespedeza*, were grown in pH 5.0 versus pH 7.0 soil. Common lespedeza was the only legume to have plant yield and plant total N unaffected by soil pH, and it was concluded that clover had the highest acid tolerance.

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[61] Note: by definition, the hawkmoths that pollinate orchids would be primarily nectar feeders

Kim, JK, and JS Kim (1989). Studies on the composition of forest vegetation and the contents of polluted material in the needles in an air polluted area. Journal of Korean Forestry Science 78(4), 360-371.

This study examined environmental effects of air pollution in the Onsan (Korea) industrial area, which is a port area. Near the pollutant source, soil pH, organic matter, total N, and number and abundance of species were low, whereas sulfur was high. *Lespedeza maritime*, a Korean plant, was found to be sensitive to air pollution. Unfortunately, the article abstract only was available since the journal does not have a website,[62] and the abstract did not explain the degree or nature of the air pollution at the Onsan site at the time of the study.

Mulder, C, T Aldenberg, D de Zwart. HJ van Wijnen, and AM Breure (2005). Evaluating the impact of pollution on plant-Lepidoptera relationships. Environmetrics 16, 357-373.

The authors created a mathematical model of ecological effects from pollutants to describe six years of monitoring data from a Dutch nature preserve. With the model they were able to determine how well various stressors predicted declines of Lepidoptera populations. The study found that while various butterfly populations are indirectly affected by sulfate, nitrate, and ammonium wet deposition via their nectar-plants, and likewise are vulnerable to heavy metal toxic pressure, moth populations are robust due to the comparative resilience of their nectar-plants.

Trumble, JT and JD Hare (1989). Acidic fog-induced changes in host-plant suitability: Interactions of *Trichoplusia ni* and *Phaselus lunata*. Journal of Chemical Ecology 15(9), 2379-2390.

Well-fertilized lima bean bushes were exposed to 2-hour nitrogen-rich acidic fogs of varying pH and the response of cabbage looper (*Lepidoptera* family) eggs and larvae were noted in controlled laboratory conditions. Plants exposed to the acidic fog developed significantly higher nitrogen levels, and the larvae ate significantly more leaf area and gained significantly more weight at fog pH 3.0 and 2.5. Egg survival did not vary significantly by fog pH. Although this study does not examine the entire insect life cycle, it suggests that fog pH alone does not significantly affect egg or larvae survival, but rather that some types of acid fog could improve the insect's feeding conditions by providing extra nitrogen and sulfur nutrients to the host plant.

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[62] See JournalSeek entry for "Journal of Korean Forestry Society", http://journalseek.net/cgi-bin/journalseek/journalsearch.cgi?field=issn&query=0445-4650 (accessed 12/10/07)

58

A.4. Summary

Hawkmoth populations can be expected to be resilient to acid or PM air pollution, more so than other Lepidoptera (such as honeydew-feeding butterflies). Diptera (another Indiana bat food) appears robust to soil acidification and sulfur accumulation, but aquatic species, like other aquatic macroinvertebrates, may or may not be detrimentally affected by surface water acidification. Clover may be tolerant to soil acidity up to a point, but extreme soil acidity could to reduce its population. Overall, the literature review does not motivate any special considerations as far as sensitivities of threatened and endangered species to effects of WMH emissions.

Appendix B. AERMOD Setup

The follow content is provided by RK & Associates, who conducted the AERMOD modeling used in the Endangered Species Evaluation.

B.1. Acid Fog Analysis

The input parameters for the Acid Fog Analysis modeling are discussed below.

Sources and Receptor Network

A receptor of interest for the acid fog evaluation was selected as described in the Acid Fog Evaluation section. The receptor is located about 540 meters west of the facility at a patch of potential endangered species habitat. The Oxidizer Stack and the Receptor of Interest are shown on figure 3.1 and UTM coordinates are given in Table 3.1. SO2 emission rate is based on potential to emit emission estimate for the proposed fifth furnace group, C5. The emission estimate includes the incremental emissions during normal Sulferox operation plus the emission estimate during malfunction. 504 hrs of Sulferox malfunction are allowed. Malfunction emissions are then spread throughout the year to receive a uniform emission rate of 14.60 g/s.

Meteorological Data

Surface meteorological data collected by the National Weather Service at the Peoria Greater Peoria airport station (WBAN: 14842) will be used for the years 2002 through 2006. The upper air data for the same time period will be used for the Central Illinois Nwfo station (WBAN: 04833). Data is processed using the AERMET module of the AERMOD modeling software. The AERMET surface parameters were provided by IEPA.

Model Settings

The AERMOD model was run with the regulatory default option, which includes the following:

- 1-hour average concentrations
- Stack tip downwash
- Calms and missing meteorological data routine
- Direction-specific building downwash
- Actual receptor elevations
- Complex/intermediate terrain algorithms (if appropriate)

60

Table 8   Source description and Receptor of Interest for Acid Fog Analysis.

Sources / Receptors	Coordinates		Emission Rate
	Easting (m)	Northing (m)	
Oxidizer Stack	307352.5	4574662.6	14.60 g/s
Receptor of Interest	306900.0	4574400.0	NA
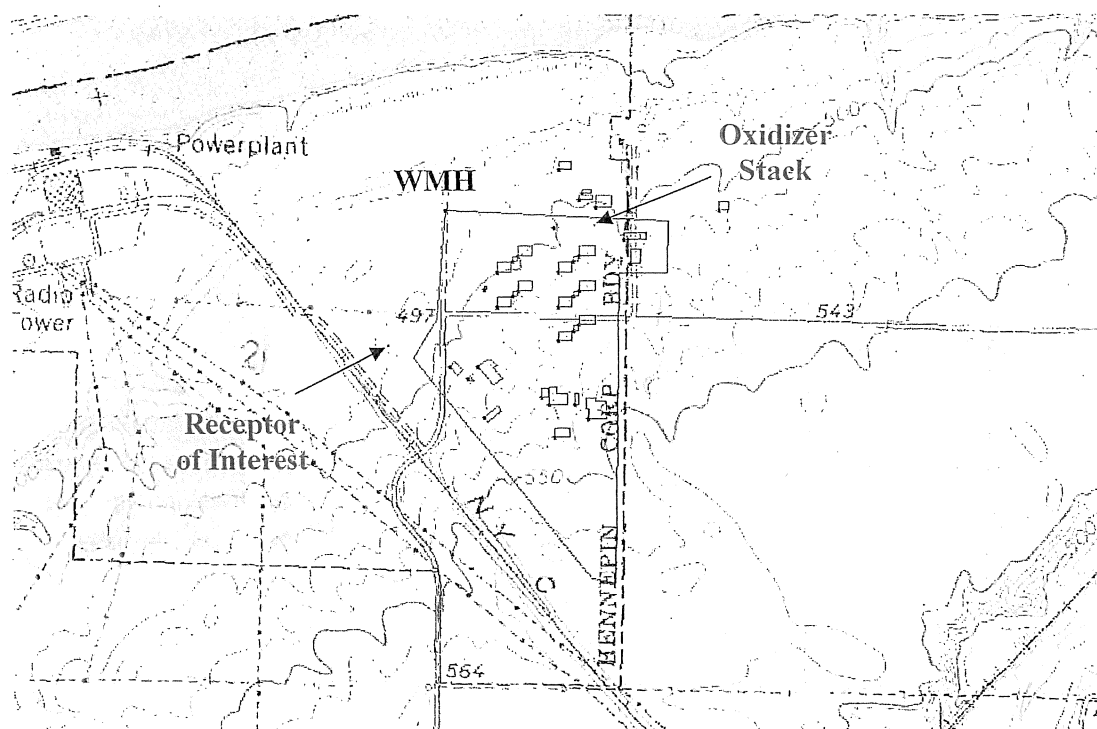
Figure 20   Location of Oxidizer Stack and Receptor of Interest.

B.2. Particulate Matter

Sources of PM10 emissions in the facility have been identified. They include the oxidizer stack, the raw material processing, the product processing, and fugitive emissions from material transfer.

Sources and Receptor Network

For this analysis a Cartesian grid was selected with the following spacing for the receptors network:

- 25 m along the facility fence line
- 250 m extending from the fence line to 2 km
- 250 m extending from 2 km to 4 km

The PM_{10} sources and their modeling parameters are presented in Table 3.2. Emissions from product processing are controlled by baghouses – C002, C003, C004, C005, C006, and C012. Emissions from raw material handling will be controlled by baghouse C013. This filter will be installed before the construction of the fifth furnace. Typical hours of operation for each source are modeled as shown in Table 3.2. Current Title V permit allows 504 hours of Sulferox malfunction operation. It is impossible to predict when a malfunction will occur therefore for modeling purposes the 504 hours of malfunction are spread evenly throughout the year. Emissions from the stack and the baghouses are modeled as point sources.

Fugitive emissions in the facility are due to equipment traffic in the yard, raw material transfer to furnace group C5, and wind erosion from storage piles. It is difficult to predict the exact location of each source as the traffic routes and the stock pile placement may change; modeling reflects the expected routes and pile locations as show on Figure 3.2. Emission rates and the hours of operation for each fugitive source are shown on Table 3.3. The following modeling assumptions are made for the fugitive sources:

1) **Equipment traffic.** Emissions are modeled as array of volume sources evenly placed on the equipment routes. 26 volume sources are modeled. The parameter for each volume source are selected as suggested by NC Quarry Guidance for Refine Modeling and the User Guide for EPA Aermod Modeling:

- adjusted road width 38 ft: 20 ft (width of equipment) plus 18 ft to account for turbulence

- height 12 ft: height of tires 6 ft times 2

- release height 6 ft

- horizontal dimension 38 ft divided by 2.15

- vertical dimension 12 ft divided by 2.15

2) Material transfer. The material transfer is done by a conveyor. The conveyor is modeled as an elevated volume source with the following parameters:
- width of conveyor 3 ft

- height of material drop 40 ft, height of pile 25 ft

- release height 32 ft

- horizontal dimension 3 ft divided by 4.3

- vertical dimension 40 ft – 25 ft = 15 ft; then 15 ft divided by 4.3

3) Storage Piles. Four storage piles are modeled as elevated area sources. The height of the area source is assumed ½ of storage pile height, or 15 ft.

Particle size distribution. Particle size distribution for the oxidizer stack is taken from particle size distribution analysis conducted on August 29, 1998. Particle size distribution for the baghouses and fugitive emissions are taken from AP-42, Appendix B.2, Table B.2.2 for category 4. Particle size distributions are shown on Table 3.4.

Meteorological Data
Same meteorological data is used as in Section 3.1 above.

Model Settings
The AERMOD model was run in non-regulatory default option with dry and wet deposition.

- 24-hour average concentrations/wet/dry deposition

- Annual concentration/wet/dry deposition

- Calms and missing meteorological data routine

- Direction-specific building downwash

- Actual receptor elevations

- Complex/intermediate terrain algorithms (if appropriate)

B.3. Metals

Nickel, Aluminum and Vanadium are found in the petroleum coke. The emissions of particulates are due to the raw material processing or source C013. Aluminum and Vanadium are found in the final product SiC. Emission of SiC particles are due to product processing or sources C002, C003, C004, C005, C006, and C012. Same emission rates and parameters are modeled as in Section 3.2 above.

Figure 21   Fugitive PM$_{10}$ Sources.
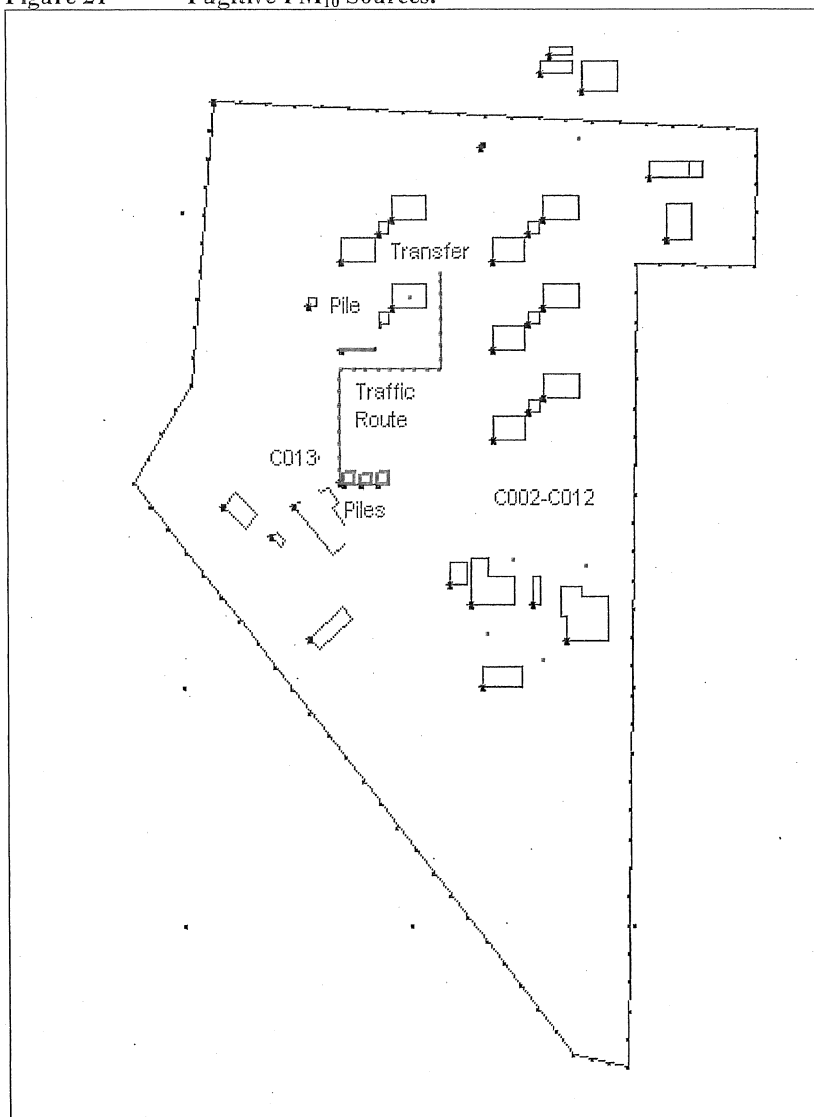
Table 9   Source Description for PM_{10} Modeling.

Emission Source	Height (ft)	Diameter (ft)	Temperature (F)	Emission Rate (lb/hr)	Typical Operations (hr)	Typical Operations (hr/day)	Typical Operations d/wk	Density (g/cm³)
C-002	6	1.83	180	0.0030	2600	8.3	6	3.22
C-003	22	2	230	0.0356	2600	8.3	6	3.22
C-004	5.25	1.69	160	0.0716	2600	8.3	6	3.22
C-005	22	1.75	115	0.0013	4980	16.0	6	3.22
C-006	25	1.17	115	0.0027	3030	9.7	6	3.22
C-012	6	2.56	180	0.0164	2600	8.3	6	3.22
C-013	6	2.5	65	1.2031	1945	7.5	5	1.0
Stack	108	8	1384	2.2900	8760	24	7	2.6
Malfunction	108	8	1384	9.2000	504	1.4	7	2.6

Table 10   Fugitive Emissions.

Process	Emission Rate (tons/yr)	Operations (hrs/yr)	Emission Rate (lbs/hr)	Number of Sources	Each Source (lbs/hr)
Equipment Traffic	5.0876	5824	1.747	26	0.0672
Storage Piles	1.21716	8760	0.278	4	0.0695
Material Transfer	0.13524	5824	0.046	1	0.0464

66

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Table 11 **Particle size distribution.**

Source	Particle Size (μm)	Mass Fraction
Oxidizer Stack	2.5	0.47
	5.0	0.28
	10.0	0.25
Baghouses & Fugitive	2.5	0.35
	5.0	0.33
	10.0	0.32

AIR AND RADIATION DIVISION CONCURRENCE SHEET

SUBJECT: _ESA Washington Mills C6_

CONTROL NUMBER (if applicable):_____

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If CONCURRENT SIGHOFF IS NECESSARY, PLEASE INDICATE NAME OF APPROPRIATE DIVISION(S)

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Assigned Staff Person	( )		
Division Director	( )		
Other	( )		

NAME OF DIVISION_____
Assigned Staff Person	( )		
Division Director	( )		
Other	( )		

OFFICE OF THE REGIONAL ADMINISTRATOR
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The originator and first level supervisor are responsible for assuring that documents are in plain language. All other reviewers should consider plain language in their reviews. For more information, see the plain language checklist on the reverse side of this sheet.

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